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The elasticity of excess demand held by foreign buyers of United States agricultural products is critical for understanding the impacts of changes in farm policy and is a parameter that is much debated. The objective of my study is to estimate this parameter for major U.S. export crops, including wheat, corn, and soybeans. I first formulate an economic model of U.S. exports including country-specific, crop-specific price transmission elasticities, supply elasticities, and demand elasticities for each of the major importers of U.S. crops. I then regress each model with updated time-series data sources, carry out extensive diagnostic tests, and incorporate these estimates into an economic model of U.S. export markets to calculate the excess demand elasticities. I provide a systematic comparison to previous estimates in the literature and find that the foreign demand for corn and soybeans tends to be fairly elastic, while the demand for wheat is relatively inelastic.

The Elasticity of Excess Demand for United States Crop Exports

by
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Dean of the Graduate School

I understand that my thesis will become part of the permanent collection of Oregon State University libraries. My signature below authorizes release of my thesis to any reader upon request.

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Xiaojuan Zheng, Author

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The Elasticity of Excess Demand for United States Crop Exports

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Abstract

The elasticity of excess demand held by foreign buyers of United States agricultural products is critical for understanding the impacts of changes in farm policy and is a parameter that is much debated. The objective of my study is to estimate this parameter for major U.S. export crops, including wheat, corn, and soybeans. I first formulate an economic model of U.S. exports including country-specific, crop-specific price transmission elasticities, supply elasticities, and demand elasticities for each of the major importers of U.S. crops. I then regress each model with updated time-series data sources, carry out extensive diagnostic tests, and incorporate these estimates into an economic model of U.S. export markets to calculate the excess demand elasticities. I provide a systematic comparison to previous estimates in the literature and find that the foreign demand for corn and soybeans tends to be fairly elastic, while the demand for wheat is relatively inelastic.

1. INTRODUCTION AND OBJECTIVES

The elasticity of excess demand held by foreign buyers of United States agricultural products is critical for understanding the impacts of changes in farm policy (Gardiner and Dixit, 1987; Carter and Gardiner, 1988). The price elasticity of excess demand is the percentage change in exports facing a country given a 1% change in its export price.

The concept of excess demand can be understand by way of the well-known three panel diagram of international trade. This is depicted in Figure 1.1. The three panels depict price (P) and quantity (Q) space for a single product for a domestic (d) market (leftmost panel), international market (middle panel), and a foreign (f) market (rightmost panel). The autarkic (without trade) price of the product in the domestic country is given by the intersection of its supply (S_d) and demand (D_d) curves in the leftmost panel. The autarkic price of the product in the foreign country is given by the intersection of its supply (S_f) and demand (D_f) curves in the rightmost panel. The autarkic price is lower in the domestic country and so it has an excess supply (ES) when graphed in the center panel. The ES is calculated as S_d less D_d for a given price P. The autarkic price is higher in the foreign country and so it has an excess demand (ED) when graphed in the center panel. The ED curve is calculated as D_f less S_f for a given price P. Note that the ED has negative slope since the difference widens at higher prices.

We can think about the domestic market as being the United States (U.S.), and the foreign market as being the rest of the world (ROW). If the excess demand curve is elastic, then U.S. exports will fall if the U.S. introduces policies that support commodity prices. The implication is that rival suppliers will respond to the higher prices and increase their share of world markets. If the excess demand curve is inelastic, then the U.S. could use land retirement and stocks policies, for example, to raise commodity prices at little cost to export volume or market share (Miller and Paarlberg, 2001). The demand for U.S. exports is more elastic when the U.S. is a small player in world markets, when importer supply and demand elasticities are elastic, or when price transmission elasticities are high. The magnitude of this parameter is much debated and in need of a firmer empirical foundation (Gardiner and Dixit, 1987; Carter and Gardiner, 1988; Miller and Paarlberg, 2001).

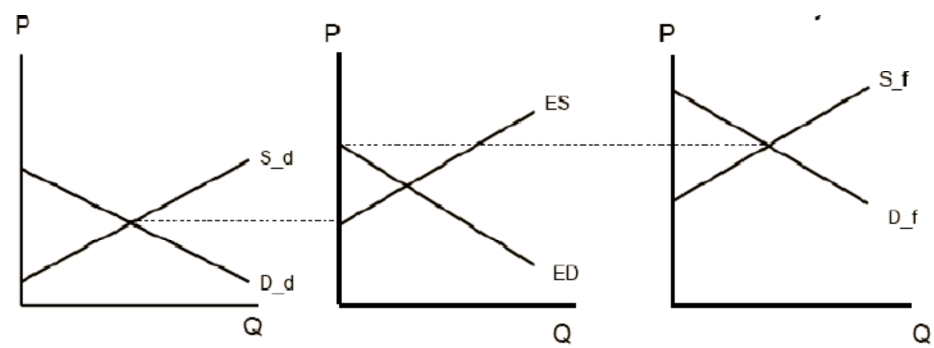

Figure 1.1 Three panel diagram of international trade

Different groups of agricultural policy researchers have very different understandings of the magnitude of export elasticities, which in turn conditions the policy analysis. Personal communication with Dr. Phil Paarlberg of Purdue University indicates that the export elasticity question is far from resolved. Within the USDA ERS the view on the size of the excess demand elasticity has changed over the last several decades. In the

1970s the prevailing view was that the excess demand elasticity is inelastic, which was viewed as relatively elastic in 1980s. At present, the excess demand elasticity may be back to being viewed as inelastic, which is closer to the perception of the 1970s.

In this thesis I seek to assess the degree to which changing perceptions stated above are based on reality. The objective of my study is to estimate excess demand elasticity for three major U.S. export crops: corn, wheat, and soybeans. Another objective is to address the contention that elasticities have been changing by providing empirical evidence of whether there has been a structural change and investigate structural stability of estimates. I seek to determine whether the U.S. is facing the same export demand as 25 years ago and to assess whether there has been a structural shift in demand, e.g., perhaps because of differentiation.

A further objective is to formulate model to estimate alternatives under short-run and long-run market conditions. I do this by differentiating between short-run and long-run supply response as well as price transmission elasticities in calculating our export demand elasticities.

A more general objective is to provide empirical evidence for how exchange rates, global market structure, policy, technological change, or commodity differentiation may influence the degree of international price competition and implications for price elasticities. Detailed analysis of these underlying factors are beyond the scope of this study, but I will provide general evidence on the aggregate nature of these effects.

For the purpose stated above, my methods include: formulating a model specification, providing justification and rational for alternative model specification, constructing time-series database for all relevant information determined by model formulation, and providing systematic comparison between existing and improved estimates including re-estimating or replication of previous estimates as necessary with updated data sources. Part of this whole process is to complete a survey of the literature and compile historical elasticity estimates, comparing them to my own estimates.

To estimate excess demand elasticities one cannot simply look at prices and export quantities over time without a statistical model (Miller and Paarlberg, 2001). Consider Table 1.1, which reports U.S. exports of wheat and the farm price of wheat over time.

Looking at Table 1.1 we see that exports are not necessarily higher or lower when the farm price is low. Since exports do not respond in a consistent way to variation in wheat prices, they might be labeled "inelastic." The problem with this simple analysis is that it suffers from the identification problem. It is not clear whether the supply or demand curve is shifting over time. Simple correlations of exports to farm prices are not an appropriate way of inferring the true, underlying elasticity. Instead, formal economic modeling and empirical model identification is needed.

Table 1.1 Exports and Prices of U.S. Wheat, Selected Years

Marketing year	1993/94	1996/97	1999/00	2002/03	2005/06	2007/08
Exports (million bu)	1228	1002	1089	850.2	1003	1264
Farm price ($/bu)	3.26	4.30	2.48	3.56	3.42	6.48

Source: USDA ERS data.

Gardiner and Dixit (1987) identify four general ways of estimating the excess demand elasticity: the Direct Estimation Method, the Simulation Method, the Synthetic Method, and the Calculation Method. I use the last of these four in the analysis. The Direct Estimation Method is the easiest way to estimate excess demand. It involves a simple reduced-form regression of exports of a commodity on the price of that commodity and the prices of other commodities. There are significant econometric shortcomings with this approach, however, such as omitted variables problems (Orcutt, 1950; Leamer and Stern, 1970; Magee, 1975). As a result, excess demand elasticities are generally biased towards being inelastic. For these reasons this approach has fallen out of favor and is not used very much anymore (Miller and Paarlberg, 2001).

Another approach is the Simulation Method (e.g., Tyers and Anderson, 1988). This relies on a multi-market multi-commodity trade simulation model, and thus captures behavioral responses to a change in export prices. Elasticities based on the simulation method do not hold all things constant, and therefore resemble “dynamic multipliers” rather than elasticities in the pure sense (Carter and Gardiner, 1987). The Simulation Method involves setting up an extensive multi-commodity, multi-regional model (such as the Global Trade Analysis Project computable general equilibrium model) and calibrating it to the economy at a particular point in time. The model is then shocked to represent a price change, and the level of response in export demands is influenced by adjustments in all of the equations. A problem with this approach, however, is that it may rely too much on theory and assumptions and not enough on historical price data and econometric methods. The results could be quite sensitive to a calibrated parameter in the model, and extensive sensitive analysis is required to get trustworthy results. This approach is also much harder to estimate, as much more information about the economy needs to be known. Many of the parameters in large simulations may be calibrated and not necessarily validated.

The Synthetic Method is mainly a review and compilation of elasticities reported in previous studies in conjunction with knowledge of the commodity market that is being examined (Gardiner and Dixit, 1987). This approach is therefore not very scientific. It does not require any data or statistical estimation procedure.

The Calculation Method has an advantage in that it is derived from primitive structural equations. In this approach, excess demand elasticities are calculated from domestic demand and supply elasticities, along with price transmission elasticities. The elasticities concern only the direct effect of a price change and do not account for cross-price effects or the indirect effects that the price change has on other economic variables such as income, foreign exchange holding, and the consumer price index (Gardiner and Dixit, 1987).

The Calculation Method has origins in Tweeten (1967), Johnson (1977), and Bredahl, Meyers, and Collins (1979). A major problem with these studies, however, is that they involve calculation of excess demand elasticities based on educated guesses about the underlying domestic supply, demand, and price transmission elasticities. In a sense, this approach (at least the way they did it) is not very empirical or scientific when judged against the modern economics literature. It has a solid theoretical basis, however, and can be adapted to improved estimation of the underlying parameters. I propose to do this in the remainder of the study, specifically, showing how the Calculation Method can be parameterized with econometric methods and historical data.

2. CONCEPTUAL MODEL

This chapter develops a conceptual framework for analyzing the research problem. The excess demand framework described in the first chapter is only for one exporting country and one importer. It also does not include an actual mathematical representation of the elasticity of the excess demand curve facing the U.S. I follow the type of derivations made in Tweeten (1967), Johnson (1977), and Bredahl, Meyers, and Collins (1979). Let i be an index of importers, $i = 1,...,m$. Let p_i denote consumer prices as well as the price received by suppliers within country *i* (internal taxes and subsidies are zero, no margins). Let p_{US} be the U.S. export price. Let Q_{ef} denote the level of U.S. exports to all countries, of which there are *m* in total. Let Q_{di} denote demand in country *i*, which can be derived theoretically by constrained utility maximization. Let Q_{si} denote supply in country *i*, which can be derived theoretically from either a technology or cost function. First let the level of U.S. exports to all countries for a given product be given by this expression:

(2.1) $$Q_{ef} = \sum_i \left[Q_{di} - Q_{si} \right].$$

Now get the elasticity by taking the derivative with respect to p_{US} :

(2.2) $$\frac{dQ_{ef}}{dp_{US}} = \sum_i \left[\frac{dQ_{di}}{dp_i} \frac{dp_i}{dp_{US}} - \frac{dQ_{si}}{dp_i} \frac{dp_i}{dp_{US}} \right],$$

(2.3) $$\frac{dQ_{ef}}{dp_{US}} \frac{p_{US}}{Q_{ef}} Q_{ef} = \sum_i \left[\frac{dp_i}{dp_{US}} \frac{p_{US}}{p_i} \left(\frac{dQ_{di}}{dp_i} \frac{p_i}{Q_{di}} Q_{di} - \frac{dQ_{si}}{dp_i} \frac{p_i}{Q_{si}} Q_{si} \right) \right],$$

(2.4) $$\frac{d\ln Q_{ef}}{d\ln p_{US}} = \sum_i \left[\frac{d\ln p_i}{d\ln p_{US}} \left(\frac{d\ln Q_{di}}{d\ln p_i}\frac{Q_{di}}{Q_{ef}} - \frac{d\ln Q_{si}}{d\ln p_i}\frac{Q_{si}}{Q_{ef}} \right) \right],$$

(2.5) $$E_{ef} = \sum_i E_{pi} \left(E_{di}\frac{Q_{di}}{Q_{ef}} - E_{si}\frac{Q_{si}}{Q_{ef}} \right).$$

where E_{ef} is U.S. excess demand elasticity, E_{pi} is the price transmission elasticity – percentage change in *i*th country's price for a percent change in U.S. price, E_{di} and E_{si} are the elasticities of domestic demand or supply in country *i*. $\frac{Q_{si}}{Q_{ef}}$ and $\frac{Q_{di}}{Q_{ef}}$ are domestic production and consumption in *i* divided by total U.S. exports to all countries.

$E_{pi} = 1$ implies perfect price transmission, which is achieved only in the classical free trade model with no transportation costs. $E_{pi} < 1$ implies there are non-zero transportation costs or some kind of policy distortion. $E_{pi} = 0$ implies that government policies completely insulate *i*'s internal production and consumption prices from world market prices.

The difficult issue is how to estimate all the components of equation (2.5). In past studies, authors have simply made assumptions about these components. For example, Johnson (1977) assumes domestic demand elasticities are -0.2 for wheat and cotton, and -0.4 for feed grains and soybeans. All supply elasticities are assumed to be 0.2. These elasticities are all taken to be net of the cross-price relations among groups, e.g., wheat and cotton. The problem with this approach is that they are merely guesses. Furthermore, these elasticities may have changed over time.

An obvious alternative to making guesses about these parameters is to estimate them econometrically. Since the costs of computing have fallen dramatically since the 1970s, and there are a much longer time series of data available, this is much easier to do than it would have been for Tweeten (1967), Johnson (1977), or Bredahl, Meyers, and Collins (1979).

In the remainder of this thesis I will estimate the price transmission elasticity (chapter 3), the elasticity of domestic demands in importing countries (chapter 4), the elasticity of domestic supply response in importing countries (chapter 5), and then combine these data with appropriate estimates of shares to get estimates of E_{ef} by commodity (chapter 6).

3. ESTIMATION OF PRICE TRANSMISSION ELASTICITIES

3.1. Model Description

An important component of the theoretical model developed in Chapter 2 is the price (*p*) transmission elasticity for importer *i*, denoted E_{pi}. To estimate E_{pi} we follow some of the earlier literature including Abbott (1979) and Mittal and Reimer (2008). This involves regressing local price associated with a 1% change in the U.S. export price. Local prices in many importing countries are constrained from directly following U.S. export prices. In cases where full adjustments never occur within a given period, Abbott (1979) proposes use of a partial-adjustment model such as:

(3.1) $$\ln p_i^t = \beta_0 + \beta_1 \ln p_i^{t-k} + \beta_2 \ln p_{US}^t + \beta_3 TREND + \varepsilon_i^t \ ,$$

where p_i^{t-1} is importer *i*'s price in the previous period, p_{US}^t is the U.S. price at time *t*, *k* is 1,2,3…, $TREND$ is a monthly time trend $1,2,3,...,$ β 's are parameters to estimate, and ε^t is an error term with classical properties, except as described below. β_2 is the short-run adjustment to U.S. price that is denoted E_{pi} above (Abbott, 1979, p. 24). It indicates the percent by which the domestic price changes in the near term as the U.S. export price increases by one percent. The long-run price transmission elasticity is simply taken to be one.

The error term is denoted ε_i^t in (3.1). It is initially assumed to have mean zero and homoskedastic variance, but I will test some of these assumptions and other assumptions of the classical linear regression model below. Based on these tests I will try to choose an estimator that is consistent in large sample sizes. I now turn to a description of the available data.

3.2. Data Description for Price Transmission Elasticities

I estimate price transmission elasticities (PTEs) for the major importers. In the case of corn these are Algeria, Brazil, China, Egypt, France, India, Italy, Japan, Korea, Mexico, and Spain. In the case of wheat the major importers are: Algeria, Brazil, China, Egypt, Indonesia, Italy, Japan, Korea, Mexico, and Spain. In the case of soybeans the major importers are: Brazil, China, Indonesia, Italy, Japan, Korea, Mexico, Spain, and Turkey. I obtain my data mostly from the USDA Global Agricultural Trade System (GATS) and the USDA, Agricultural Marketing Service, Grain and Feed Market News. Descriptive statistics are reported in Tables 3.1-3.3.

Unit values are the commodity total expenditure divided by physical quantity. Ideally I would use prices instead of unit values. Unit values are not an actual transaction price. They are just an approximation. Therefore, the use of unit value as a proxy for price can give rise to measurement error. In one case (Japan) I was able to obtain high quality price data. To see how good the unit values are, I compared these actual prices to the unit values. In the case of wheat, corn, and soybeans the correlation between the unit value and the price is 0.98, 0.95, and 0.95, respectively. I conclude that use of unit values may not cause major problems in the analysis.

Table 3.1 Descriptive Statistics of Variables for Corn Price Transmission Model

Variables	Description	Source	Mean	Min	Max	Count
p_{US}^{t}	Corn No. 2 yellow, U.S. Gulf ports, LA ($/MT)	B	108	61	268	408
$p_{Algeria}^{t}$	Unit value, monthly free alongside ship price ($/MT)	A	113	54	222	343
p_{Brazil}^{t}	Unit value, monthly free alongside ship price ($/MT)	A	125	76	478	117
p_{China}^{t}	Unit value, monthly free alongside ship price ($/MT)	A	146	71	524	130
p_{Egypt}^{t}	Unit value, monthly free alongside ship price ($/MT)	A	120	65	348	386
p_{France}^{t}	Unit value, monthly free alongside ship price ($/MT)	A	153	67	968	105
p_{India}^{t}	Unit value, monthly free alongside ship price ($/MT)	A	161	94	360	50
p_{Italy}^{t}	Unit value, monthly free alongside ship price ($/MT)	A	125	66	636	212
p_{Japan}^{t}	Unit value, monthly free alongside ship price ($/MT)	A	122	73	295	408
p_{Korea}^{t}	Unit value, monthly free alongside ship price ($/MT)	A	133	69	902	401
p_{Mexico}^{t}	Unit value, monthly free alongside ship price ($/MT)	A	125	78	295	408
p_{Spain}^{t}	Unit value, monthly free alongside ship price ($/MT)	A	128	60	398	332

Notes: Time series: Sep, 1975 to Dec, 2007. A is USDA GATS; B is USDA, Agricultural Marketing Service, Grain and Feed Market News. V is variables. C is Japan Customs, data source started from Feb, 1994 to Dec, 2007. We delete cases where the shipments were less than 10 MT in a month. For econometric analysis, these prices are divided by a GDP deflator (Price Level of Gross Domestic Product, unit: US=100 in Current Prices) (http://pwt.econ.upenn.edu/php_site/pwt63/pwt63_form.php).

Table 3.2 Descriptive Statistics of Variables for Wheat Price Transmission Model

Variables	Description	Source	Mean	Min	Max	Count
p_{US}^{t}	Wheat No. 1 hard red winter (ordinary protein), Kansas City, MO, Cash	B	143	51	452	471
$p_{Algeria}^{t}$	Unit value, monthly free alongside ship price (current $/MT)	A	143	53	346	346
p_{Brazil}^{t}	Unit value, monthly free alongside ship price (current $/MT)	A	148	45	517	259
p_{China}^{t}	Unit value, monthly free alongside ship price (current $/MT)	A	145	61	381	318
p_{Egypt}^{t}	Unit value, monthly free alongside ship price (current $/MT)	A	142	69	395	398
p_{India}^{t}	Unit value, monthly free alongside ship price (current $/MT)	A	139	54	270	182
p_{Italy}^{t}	Unit value, monthly free alongside ship price (current $/MT)	A	173	53	470	387
p_{Japan}^{t}	Unit value, monthly free alongside ship price (current $/MT)	A	164	56	597	471
p_{Japan}^{t}	Wheat and Meslin monthly average price ($/MT)	C	209	155	423	167
p_{Korea}^{t}	Unit value, monthly free alongside ship price (current $/MT)	A	155	54	570	469
p_{Mexico}^{t}	Unit value, monthly free alongside ship price (current $/MT)	A	158	55	492	397
p_{Spain}^{t}	Unit value, monthly free alongside ship price (current $/MT)	A	957	2	41330	136

Notes: Time series: Oct, 1970 to Dec, 2007. A refers to the USDA GATS; B refers to USDA, Agricultural Marketing Service, Grain and Feed Market News. C is Japan Customs.

Table 3.3 Descriptive Statistics of Variables for Soybeans Price Transmission Model

Variables	Description	Source	Mean	Min	Max	Count
p_{US}^{t}	Soybean price, No. 1 yellow, Chicago, $/MT	B	220	87	556	512
p_{Brazil}^{t}	Unit value, monthly free alongside ship ($/MT)	A	243	95	500	54
p_{China}^{t}	Unit value, monthly free alongside ship ($/MT)	A	272	176	607	204
p_{Egypt}^{t}	Unit value, monthly free alongside ship ($/MT)	A	278	165	690	128
$p_{Indonesia}^{t}$	Unit value, monthly free alongside ship ($/MT)	A	267	156	550	257
p_{India}^{t}	Unit value, monthly free alongside ship ($/MT)	A	431	105	2667	12
p_{Italy}^{t}	Unit value, monthly free alongside ship ($/MT)	A	266	19	875	434
p_{Japan}^{t}	Unit value, monthly free alongside ship ($/MT)	A	242	91	533	512
p_{Japan}^{t}	Monthly Soybeans average price (current $/MT)	C	302	214	486	167
p_{Korea}^{t}	Unit value, monthly free alongside ship ($/MT)	A	257	91	1444	412
p_{Spain}^{t}	Unit value, monthly free alongside ship ($/MT)	A	231	90	857	395
p_{Mexico}^{t}	Unit value, monthly free alongside ship ($/MT)	A	249	61	698	468
p_{Turkey}^{t}	Unit value, monthly free alongside ship ($/MT)	A	262	173	568	162

Notes: Soybean price is U.S. average price received by farmers, $/MT (from Feb, 1967 to Aug, 2007). A refers to the USDA GATS; B refers to USDA, Agricultural Marketing Service, Grain and Feed Market News. C is Japan Customs, data source started from Feb, 1994 to Dec, 2007.

3.3. Violations of the Classical Linear Regression Model

In this section I consider reasons why the econometric model may not conform to the assumptions of the classical linear regression model. It assumes linearity, full rank (no exact linear relationship among independent variables), exogeneity of the independent variables (none is correlated with the error term), homoscedasticity and nonautocorrelation (each error term has the same finite variance, is uncorrelated with every other disturbance, and has mean zero).

Nonstationarity: Given the time-series nature of the data, I first investigate the dynamic properties of the price series. If the series are nonstationary then the least squares estimator does not have its usual properties and *t*-statistics are not reliable. The danger is that regression results may indicate a significant relationship when there is none.

I test whether the price series are stationary using a Dickey-Fuller test (a constant is included but no trend is included). The null hypothesis is that the series is nonstationary (Hill, Griffiths, and Lim, 2008, p. 335). Results for corn, wheat, and soybeans are presented in Tables 3.4, 3.5, and 3.6, respectively. All numbers listed in the Tables are *p*-values. For corn, in 9 out of 11 countries we reject this null hypothesis at the 5% significance level. For wheat, in 4 out of 10 countries we reject this null hypothesis at the 5% significance level. For soybeans, in 8 out of 10 countries we reject this null hypothesis at the 5% significance level. It appears that the price series for most countries and commodities are stationary. On the whole this does not seem like a major issue for this particular line of research, and so no adjustments are made in this regard. Therefore I do not take corrective measures. In part a concern about nonstationarity is also lessened by the fact that I do not seek to test hypotheses regarding long-run causal relationships, such as the existence of the Law of One Price, existence of exchange-rate pass through, or other forms of market integration. My objectives are relatively moderate, as I am mainly trying to gauge the magnitude of price adjustments between two variables that are without question going to be highly related.

Homoscedastic variance: The classical linear regression model assumes homoskedastic variance. In the PTE model, this implies that at each U.S. price level and each lagged domestic price, we are equally uncertain about how far the domestic price paid falls from its mean value. I can test for this using the Breusch-Pagan test, which tests whether the estimated variance of the error terms are dependent on the values of the independent variables. The test proceeds by first estimating the regression model, and then squaring the residuals and regressing them on the independent variables. If the estimated coefficients on the independent variables are jointly significant then we reject a null hypothesis of homoscedastic variance. For corn, in 2 out of 11 countries we reject this null hypothesis at the 5% significance level. For wheat, in 5 out of 10 countries we reject this null hypothesis at the 5% significance level. For soybeans, in 4 out of 10 countries we reject this null hypothesis at the 5% significance level.

Autocorrelation: Since this is a time series analysis, autocorrelation is potentially a problem, that is, off-diagonal entries in the variance-covariance matrix may not all be zeros. This could arise for several reasons, including spatial autocorrelation, prolonged influence of shocks, inertia, data manipulation, and mis-specification. To determine if the disturbances actually are autocorrelated, we carry out the Breusch-Godfrey serial correlation LM test, which is a robust test for autocorrelation in the residuals from a regression analysis and is more general than the standard Durbin-Watson statistic or Durbin's *h* statistic. The null hypothesis is that there is no autocorrelation of any order. For corn and without a trend, in 6 out of 11 countries we reject this null hypothesis at the 5% significance level. For wheat and without a trend, in 6 out of 10 countries I reject this null hypothesis at the 5% significance level. For soybeans and without a trend, in 4 out of 9 countries we reject this null hypothesis at the 5% significance level.

I also tried including a trend on the right hand side. Things change somewhat when we have a trend. For corn with a trend, in 6 out of 11 countries we reject this null hypothesis at the 5% significance level. For wheat with a trend, in 6 out of 10 countries we reject this null hypothesis at the 5% significance level. For soybean with a trend, in 5 out of 10 countries we reject this null hypothesis at the 5% significance level.

Endogeneity: One issue is the potential endogeneity of the lagged value of the dependent variable on the right-hand side (p_i^{t-1}) in equation (3.1). If this is not independent of the error terms, then ordinary least squares (OLS) estimation may give rise to biased estimates in small samples. This consideration is offset, however, by the fact that equation (3.1) is a partial-adjustment model for which the parameters can be consistently and efficiently estimated by ordinary least squares (Greene, 2004, p. 568). Also, as long as there is no time series autocorrelation, the lagged dependent variable can be taken as exogenous in a given time period *t*. Given that I did encounter autocorrelation for the time series of most countries, I have decided to go with the autocorrelation corrected errors in the remainder of the analysis.

As the assumption of nonautocorrelation is violated for most equations, the OLS estimator will be unbiased but inefficient, with the true variance of the estimators being underestimated. An estimator with better properties under first-order autoregressive AR (1) errors is the Restricted Maximum Likelihood (REML) estimator (Greene, 2004, p. 527 and 649). Its approach is a particular form of maximum likelihood estimation which does not use the full set of observations available. In contrast to maximum likelihood estimates, REML estimates of variances and covariances are unbiased. I report autocorrelation-corrected short-run PTE estimates for corn, wheat, and soybeans in Tables 3.7, 3.8, and 3.9, respectively.

Table 3.4 Diagnostic Tests for Corn

Test:	Augmented Dickey-Fuller	Breusch-Pagan	Breusch-Godfrey without *TREND*	Breusch-Godfrey with *TREND*
Null hyp:	Nonstationary	Homoscedasticity	No autocorrelation up to order 1 AR(1)	No autocorrelation up to order 1 AR(1)
Algeria	0.005***	0.059*	<0.001***	<0.001***
Brazil	<0.001***	0.642	0.000***	0.001***
China	<0.001***	0.002***	0.077*	0.002***
Egypt	0.037**	0.393	<0.001***	<0.001***
France	<0.001***	0.795	0.465	0.488
India	0.045**	0.672	0.028**	0.204
Italy	<0.001***	0.963	0.093*	0.095*
Japan	0.043**	0.297	0.083*	0.136
Japan†	0.036**	0.734	<0.001***	0.000***
Korea	0.263	0.113	0.004***	0.001***
Mexico	0.260	0.947	<0.001***	<0.001***
Spain	0.002***	0.014**	0.871	0.637

Notes: All values are *p*-values.
*denotes statistical significance at the 0.10 level.
** denotes statistical significance at the 0.05 level.
*** denotes statistical significance at the 0.01 level.

Table 3.5 Diagnostic Tests for Wheat

Test:	Augmented Dickey-Fuller	Breusch-Pagan	Breusch-Godfrey without *TREND*	Breusch-Godfrey with *TREND*
Null hyp:	Nonstationary	Homo-scedasticity	No autocorrelation up to order 1 AR(1)	No autocorrelation up to order 1 AR(1)
Algeria	0.076*	0.388	0.004***	0.002***
Brazil	0.283	0.993	0.165**	0.069*
China	0.197	0.131	0.003***	0.015**
Egypt	0.899	0.001***	0.134	0.143
India	0.748	0.641	0.206	0.286
Italy	<0.001***	0.015**	0.068*	0.059*
Japan	0.938	0.019**	0.006***	0.006***
Japan†	0.832	0.000***	0.036**	0.049**
Korea	0.116	0.786	<0.001***	<0.001***
Mexico	0.001***	0.034**	<0.001***	<0.001***
Spain	<0.001***	0.048**	0.842	0.853

Notes: All values are *p*-values.
*denotes statistical significance at the 0.10 level.
** denotes statistical significance at the 0.05 level.
*** denotes statistical significance at the 0.01 level.

Table 3.6 Diagnostic Tests for Soybeans

Importers	Augmented Dickey-Fuller	Breusch-Pagan	Breusch-Godfrey without *TREND*	Breusch-Godfrey with *TREND*
Null hyp.	Nonstationary	Homoscedasticity	No autocorrelation up to order 1 AR(1)	No autocorrelation up to order 1 AR(1)
Brazil	<0.001***	0.001***	0.466	0.517
China	<0.001***	0.493	0.773	0.900
Indonesia	0.129	0.387	0.047**	0.027**
Italy	<0.001***	0.720	<0.001***	<0.001***
Japan	<0.001***	0.001***	0.814	0.004***
Japan†	<0.001***	0.024**	0.933	0.156
Korea	<0.001***	0.525	0.002**	0.001***
Mexico	0.337	0.182	<0.001***	<0.001***
Rotterdam	0.001***	<0.001***	0.001***	0.001***
Spain	<0.001***	0.303	0.144	0.070*
Turkey	0.228	0.024**	0.236	0.396

Notes: All values are *p*-values.
*denotes statistical significance at the 0.10 level.
** denotes statistical significance at the 0.05 level.
*** denotes statistical significance at the 0.01 level.

Table 3.7 Preferred Short-run Price Transmission Elasticities for Corn (REML)

Importers	$\hat{\beta}_0$ (intercept)	$\hat{\beta}_1$ (lagged own price)	$\hat{\beta}_2$ (lagged U.S. price)	$\hat{\beta}_3$ (trend)
Algeria	0.005	0.521***	0.499***	-0.001**
	(0.043)	(0.034)	(0.037)	(0.000)
Brazil	0.079	0.738***	0.252***	<0.001
	(0.222)	(0.078)	(0.079)	(0.001)
China	1.237	0.299**	0.283***	0.002***
	(0.251)	(0.120)	(0.101)	(0.000)
Egypt	0.083	0.538***	0.452***	-4.51E-6
	(0.022)	(0.028)	(0.027)	(0.000)
France	-0.089	-0.082	1.218**	-0.002
	(0.964)	(0.268)	(0.460)	(0.000)
India	6.253	0.314*	0.165**	0.004***
	(2.276)	(0.162)	(0.564)	(0.001)
Italy	0.364	0.222**	0.674***	0.003
	(0.151)	(0.057)	(0.074)	(0.000)
Japan	0.030	0.630***	0.379***	<0.001*
	(0.015)	(0.018)	(0.017)	(0.000)
Japan†	0.022	0.845***	0.163***	0.002***
	(0.041)	(0.026)	(0.023)	(0.000)
Korea	0.144	0.520***	0.455***	-0.001
	(0.073)	(0.037)	(0.038)	(0.000)
Mexico	0.143	0.695***	0.274***	-0.001
	(0.030)	(0.022)	(0.019)	(0.000)
Spain	0.173	0.240***	0.721***	0.002***
	(0.100)	(0.054)	(0.059)	(0.000)

Notes: Time series: 1975 Oct.-2007 Dec. Standard error is in parenthesis. India is using p^{t-2} .Dependent variable: importer *i*'s corn price in time *t*. Explanatory variable: importer *i*'s corn price in previous time *(t-1)* and US exporting price for corn in time *t*. †: These prices are collected from Japan Customs, from Oct, 1994 to Dec, 2007. All prices are divided by GDP deflator.
*denotes statistical significance at the 0.10 level.
** denotes statistical significance at the 0.05 level.
*** denotes statistical significance at the 0.01 level.

Table 3.8 Preferred Short-run Price Transmission Elasticities for Wheat (REML)

Importers	$\hat{\beta}_0$ (intercept)	$\hat{\beta}_1$ (lagged own price)	$\hat{\beta}_2$ (lagged U.S. price)	$\hat{\beta}_3$ (trend)
Algeria	-0.147	0.783***	0.278***	-0.001***
	(0.079)	(0.034)	(0.043)	(0.000)
Brazil	-0.044	0.698***	0.334***	-0.003**
	(0.056)	(0.056)	(0.062)	(0.000)
China	0.279	0.810***	0.087***	0.001***
	(0.094)	(0.032)	(0.029)	(0.000)
Egypt	0.054	0.748***	0.237***	-0.003
	(0.038)	(0.029)	(0.028)	(0.000)
India	0.204	0.716***	0.225***	0.003
	(0.129)	(0.048)	(0.049)	(0.000)
Italy	0.302	0.532***	0.382***	0.001
	(0.103)	(0.044)	(0.052)	(0.000)
Japan	0.044	0.789***	0.205***	7.845E-6
	(0.021)	(0.016)	(0.015)	(0.000)
Japan†	0.038	0.826***	0.149***	0.001**
	(0.070)	(0.038)	(0.026)	(0.000)
Korea	0.024	0.692***	0.312***	-0.001**
	(0.038)	(0.022)	(0.021)	(0.000)
Mexico	0.086	0.671***	0.315 ***	-0.005
	(0.059)	(0.036)	(0.037)	(0.000)
Spain	-0.203	0.871***	0.224	-0.007
	(0.500)	(0.058)	(0.166)	(0.000)

Notes: Time series: 1970 Oct.-2007 Dec. Standard error is in parenthesis. Dependent variable: importer *i*'s wheat price in time *t*. Explanatory variable: importer *i*'s wheat price in previous time *(t-1)* and US exporting price for wheat in time *t*. All prices are divided by GDP deflator.
*denotes statistical significance at the 0.10 level.
** denotes statistical significance at the 0.05 level.
*** denotes statistical significance at the 0.01 level.

Table 3.9 Preferred Short-run Price Transmission Elasticities for Soybeans (REML)

Importers	$\hat{\beta}_0$ (intercept)	$\hat{\beta}_1$ (lagged own price)	$\hat{\beta}_2$ (lagged U.S. price)	$\hat{\beta}_3$ (trend)
Brazil	-0.307	0.782***	0.230*	0.000
	(0.199)	(0.166)	(0.161)	(0.000)
China	0.231	0.140**	0.794***	0.004***
	(0.127)	(0.064)	(0.062)	(0.000)
Egypt	-0.002	0.441***	0.571***	0.001
	(0.063)	(0.091)	(0.085)	(0.000)
Indonesia	0.262	0.426***	0.516***	0.002***
	(0.077)	(0.046)	(0.045)	(0.000)
Italy	0.160	0.624 ***	0.317***	0.004***
	(0.118)	(0.039)	(0.044)	(0.000)
Japan	0.003	0.611***	0.389***	0.001***
	(0.022)	(0.017)	(0.016)	(0.000)
Japan†	-0.048	0.794***	0.201***	0.000***
	(0.054)	(0.027)	(0.023)	(0.000)
Korea	0.256	0.440***	0.502***	0.003
	(0.075)	(0.036)	(0.035)	(0.000)
Mexico	0.094	0.728***	0.255***	-6.41E-6
	(0.050)	(0.029)	(0.029)	(0.000)
Rotterdam	1.300	-0.047	0.735***	-0.001
	(12.352)	(0.031)	(0.030)	(0.002)
Spain	0.124	0.283***	0.688***	0.001***
	(0.053)	(0.035)	(0.039)	(0.000)
Turkey	0.613	0.417***	0.450***	-0.002
	(0.187)	(0.098)	(0.085)	(0.000)

Notes: Time series: 1967 Feb.-2007 Dec. Standard error is in parenthesis. Dependent variable: importer *i*'s soybean price in time *t*. Explanatory variable: importer *i*'s soybean price in previous time *(t-1)* and US exporting price for soybeans in time *t*. †: These prices are collected from Japan Customs, from Feb, 1994 to Dec, 2007. All prices are divided by GDP deflator.
*denotes statistical significance at the 0.10 level.
** denotes statistical significance at the 0.05 level.
*** denotes statistical significance at the 0.01 level.

3.4. Estimated Short-run Price Transmission Elasticities

Tests of the assumptions of the classical linear regression model were examined in the previous section. Although I tried the OLS estimator for some versions of the model, below I only report the estimation results of PTE model by using Restricted Maximum Likelihood (REML) estimator for corn, wheat and soybeans, whose variance and covariance are unbiased. The estimates of the key coefficients ($\hat{\beta}_2$) do not in general differ very much from the OLS estimates, whether or not a trend is included. Nearly all of the PTE estimates lie within the (0, 1) interval, which is what we expect given the theory underlying the PTE model. And nearly all of the results are statistically significant at 5% level.

Estimations of short-run price transmission elasticities are listed in Table 3.7 to 3.9. There are four columns in each table. $\hat{\beta}_2$ is the interested parameter, which is associated with lagged U.S. export price. Standard error is in parenthesis. Table 3.7 shows that relatively low elasticities prevail in importing countries, with estimates of $\hat{\beta}_2$ ranging from 0.163 to 0.499 for Japan, Brazil, Mexico, China, Egypt, Korea and Algeria. By contrast, Spain and France have high levels of transmission, estimates of $\hat{\beta}_2$ range from 0.715 to 1.218, respectively. The coefficient of $\hat{\beta}_2$ for India (0.165) is estimated with using p^{t-2} in place of p^{t-1} in equation 3.1, since it is monthly data and it may take a number of months before prices in the foreign country respond to changes in the U.S. price. The price transmission elasticities for Japan always fall for corn wheat, and soybeans when the price data changed from unit value to real average price collected from Japan Customs.

Table 3.8 shows that all of the countries have relatively low elasticities with estimates of $\hat{\beta}_2$ ranging from 0.087 to 0.382. These results are largely consistent with what Conforti (2004) finds in the case of maize and wheat. In a somewhat different type of analysis than what is done here, he finds evidence of long run equilibrium in the spatial transmission between the domestic and the world reference prices of wheat and maize.

In contrast to the case of corn and wheat, relatively high elasticities exist in most of the importing countries for soybeans, which are listed in Table 3.9. Estimates of $\hat{\beta}_2$ ranges from 0.502 to 0.735 for Korea, Indonesia, Egypt, Spain, EU-27, and China respectively. Japan, Brazil, and Mexico, however, still have low levels of transmission elasticities, which are 0.201, 0.230, and 0.255 respectively. To the extent that these estimates can be compared to the previous literature, they appear to be largely consistent with what has been found before (Abbott, 1979; Conforti, 2004; Reimer and Mittal, 2008). Price transmission elasticities are less than one for crops indicates that tariffs and non-tariff barriers (policy, and transportation costs) are reflected in the model.

4. ESTIMATION OF DOMESTIC DEMAND ELASTICITIES

4.1. Model Description

The above chapter shows that many of the countries that import from the U.S. have low price transmission elasticities. As shown in Chapter 2, another determinant of the excess demand facing the U.S. for exports of major crops is the domestic demand elasticity (E_{di}) in importing countries. To estimate E_{di} I need to estimate a demand function for each importer *i*. I use the following logarithmic model of demand for a given grain:

$$(4.1) \qquad \ln Q^t = \delta_0 + \delta_1 \ln p^t + \sum_{j=2}^{n} \delta_j \ln Z_j^t + \varepsilon^t .$$

This type of equation could arise from a consumer utility maximization problem as discussed in Sadoulet and de Janvry (1995). I have suppressed the importer index *i* for notational simplicity. In (4.1) the δ's are parameters to be estimated, Q^t is consumption of a grain at time *t*, and Z_j^t are additional potential explanatory variables such as prices of substitutes, income, population, employment, inflation, and various policies as appropriate. The estimate of δ_1 in this log-log model is the elasticity of demand E_{di}. The error term is ε^t and is assumed to have classical properties, although these are tested for below.

4.2. Data Description for Domestic Demand Elasticities

The data for domestic demand elasticity model are mainly searched from the USDA Global Agricultural Trade system and USDA PSD online. Unit value, annual free alongside ship price (current $/MT) is applied, which is the same as the PTE model. Besides, per capita GDP and population trend are added as the potential variables (Z_j^t). In the case of corn, the major importers estimated in this model are Algeria, Brazil, China, Egypt, India, Japan, Korea, and Mexico. In the case of wheat the major importers are: Algeria, Brazil, China, Egypt, Japan, Korea, and Mexico. In the case of soybeans the major importers are: Brazil, China, Indonesia, Japan, Mexico, Korea, and Turkey.

Table 4.1 Descriptive Statistics of Variables for Corn Domestic Demand Model

Variables	Description	Source	Mean	Min	Max	Count
$Q^t_{Algeria}$	Annual domestic consumption of corn at time *t* (1000 MT)	D	997	109	2300	33
Q^t_{Brazil}	Annual domestic consumption of corn at time *t* (1000 MT)	D	28791	16040	42500	33
Q^t_{China}	Annual domestic consumption of corn at time *t* (1000 MT)	D	88859	43570	149000	33
Q^t_{Egypt}	Annual domestic consumption of corn at time *t* (1000 MT)	D	7119	3248	11300	33
Q^t_{Japan}	Annual domestic consumption of corn at time *t* (1000 MT)	D	14959	7925	17200	33
Q^t_{India}	Annual domestic consumption of corn at time *t* (1000 MT)	D	9440	5769	14200	33
Q^t_{Korea}	Annual domestic consumption of corn at time *t* (1000 MT)	D	5892	888	9149	33
Q^t_{Mexico}	Annual domestic consumption of corn at time *t* (1000 MT)	D	18382	1057	32000	33
$P^t_{Algeria}$	Unit value, annual free alongside ship price (current $/MT)	A	112	70	164	33
P^t_{Brazil}	Unit value, annual free alongside ship price (current $/MT)	A	136	83	353	26
P^t_{China}	Unit value, annual free alongside ship price (current $/MT)	A	158	98	597	25
P^t_{Egypt}	Unit value, annual free alongside ship price (current $/MT)	A	115	77	165	33
P^t_{Japnan}	Unit value, annual free alongside ship price (current $/MT)	A	117	79	176	33
P^t_{India}	Unit value, annual free alongside ship price (current $/MT)	A	153	94	241	15
P^t_{Italy}	Unit value, annual free alongside ship price (current $/MT)	A	157	72	978	33
P^t_{Korea}	Unit value, annual free alongside ship price (current $/MT)	A	119	78	180	33
P^t_{Mexico}	Unit value, annual free alongside ship price (current $/MT)	A	120	84	182	33
$Z^t_{Algeria}$	Per Capita GDP, US dollars	E	63	21	135	33
Z^t_{Brazil}	Per Capita GDP, US dollars	E	59	12	101	33
Z^t_{China}	Per Capita GDP, US dollars	E	24	2	89	33
Z^t	Per Capita GDP, US dollars	E	27	7	65	33
Z^t_{Japan}	Per Capita GDP, US dollars	E	188	55	319	33
Z^t_{India}	Per Capita GDP , US dollars	E	76	11	173	33
Z^t_{Korea}	Per Capita GDP, US dollars	E	109	13	249	33
Z^t	Per Capita GDP, US dollars	E	68	26	123	33

Notes: Time series: 1976-2007. A refers to the USDA GATS, D refers to the USDA PSD online, E refers to Center for International Comparisons of Production, Income and Prices at the University of Pennsylvania.

Table 4.2 Descriptive Statistics of Variables for Wheat Domestic Demand Model

Variables	Description	Source	Mean	Min	Max	Count
$Q^t_{Algeria}$	Annual domestic consumption of wheat at time *t* (1000 MT)	D	5249	2081	8050	38
Q^t_{Brazil}	Annual domestic consumption of wheat at time *t* (1000 MT)	D	7957	3689	10450	38
Q^t_{China}	Annual domestic consumption of wheat at time *t* (1000 MT)	D	97518	52887	110278	35
Q^t_{Egypt}	Annual domestic consumption of wheat at time *t* (1000 MT)	D	10408	5733	15950	38
Q^t_{Japan}	Annual domestic consumption of wheat at time *t* (1000 MT)	D	6092	5737	6,418	38
Q^t_{Korea}	Annual domestic consumption of wheat at time *t* (1000 MT)	D	3163	1691	5619	38
Q^t_{Mexico}	Annual domestic consumption of wheat at time *t* (1000 MT)	D	4714	2990	6200	38
$P^t_{Algeria}$	Unit value, annual free alongside ship price (current $/MT)	A	157	60	338	38
P^t_{Brazil}	Unit value, annual free alongside ship price (current $/MT)	A	148	55	332	37
P^t_{China}	Unit value, annual free alongside ship price (current $/MT)	A	151	62	381	34
P^t_{Egypt}	Unit value, annual free alongside ship price (current $/MT)	A	143	96	285	37
P^t_{Japnan}	Unit value, annual free alongside ship price (current $/MT)	A	164	57	440	38
P^t_{Korea}	Unit value, annual free alongside ship price (current $/MT)	A	155	57	401	38
P^t_{Mexico}	Unit value, annual free alongside ship price (current $/MT)	A	155	64	370	38
$Z^t_{Algeria}$	Per Capita GDP at current prices, US dollars	E	1894	376	3912	38
Z^t_{Brazil}	Per Capita GDP at current prices, US dollars	E	2742	441	6852	38
Z^t_{China}	Per Capita GDP at current prices, US dollars	E	618	112	2604	38
Z^t_{Egypt}	Per Capita GDP at current prices, US dollars	E	805	210	1,770	38
Z^t_{Japan}	Per Capita GDP at current prices, US dollars	E	20966	1945	41823	38
Z^t_{Korea}	Per Capita GDP at current prices, US dollars	E	6342	279	19841	38
Z^t_{Mexico}	Per Capita GDP at current prices, US dollars	E	3522	761	8386	38

Notes: Time series: 1971-2009. A refers to the USDA GATS, D refers to the USDA PSDonline. E refers to Center for International Comparisons of Production, Income and Prices at the University of Pennsylvania.

Table 4.3 Descriptive Statistics of Variables for Soybeans Domestic Demand Model

Variables	Description	Source	Mean	Min	Max	Count
Q^t_{Brazil}	Annual domestic consumption of soybean at time *t* (1000 MT)	D	2633	1932	3475	20
Q^t_{China}	Annual domestic consumption of soybean at time *t* (1000 MT)	D	2737	199	9693	30
Q^t_{Egypt}	Annual domestic consumption of soybean at time *t* (1000 MT)	D	162	19	659	21
$Q^t_{Indonesia}$	Annual domestic consumption of soybean at time *t* (1000 MT)	D	14	1	40	25
Q^t_{Japan}	Annual domestic consumption of soybean at time *t* (1000 MT)	D	655	513	731	33
Q^t_{Mexico}	Annual domestic consumption of soybean at time *t* (1000 MT)	D	504	123	939	33
P^t_{Brazil}	Unit value, annual free alongside ship price (current $/MT)	A	212	118	303	27
P^t_{China}	Unit value, annual free alongside ship price (current $/MT)	A	258	187	526	28
P^t_{Egypt}	Unit value, annual free alongside ship price (current $/MT)	A	248	177	322	28
$P^t_{Indonesia}$	Unit value, annual free alongside ship price (current $/MT)	A	246	156	327	33
P^t_{Japnan}	Unit value, annual free alongside ship price (current $/MT)	A	233	97	334	41
P^t_{Mexico}	Unit value, annual free alongside ship price (current $/MT)	A	235	104	329	41
Z^t_{Brazil}	Per Capita GDP at current prices, US dollars	E	2742	441	6852	38
Z^t_{China}	Per Capita GDP at current prices, US dollars	E	618	112	2604	38
Z^t_{Egypt}	Per Capita GDP at current prices, US dollars	E	805	210	1770	38
Z^t_{Japan}	Per Capita GDP at current prices, US dollars	E	20965	1945	41823	38
Z^t_{Mexico}	Per Capita GDP at current prices, US dollars	E	3522	761	8386	38

Notes: Time series: 1976-2007. A refers to the USDA GATS, D refers to the USDA PSDonline, E refers to Center for International Comparisons of Production, Income and Prices at the University of Pennsylvania. Soybean price: No. 1 yellow, Chicago, current$/MT.

4.3. Violations of the Classical Linear Regression Model

There are a number of reasons why least squares may not be the best estimator for the parameters of equation (4.1): there may be nonstationarity, heteroscedasticity, and autocorrelation problems. I now consider the possibility of these in turn:

Nonstationarity: In the previous chapter on price transmission elasticities, I already tested for nonstationarity for the price variables that I use, once again, in this chapter. In general the deflated price series were found to be stationary, so we do not make any adjustments here.

Heteroscedasticity: The classical linear regression model assumes homoscedastic variance. Firstly I test the heteroscedasticity in an informal way: plot regression residuals against income for some major countries. Then, likewise, I use the Breusch-Pagan test to detect whether the estimated variance of the error terms are dependent on the values of the independent variables. For corn, in 4 out of 8 countries we reject this null hypothesis at the 5% significance level. For wheat, in 1 out of 7 countries we reject this null hypothesis at the 5% significance level. For soybeans, in 1 out of 6 countries we reject this null hypothesis at the 5% significance level.

Autocorrelation: For this model, before I carry out the Breusch-Godfrey serial correlation LM test, I firstly do an informal test of its presence: the regression residuals of the linear model are plotted against time for each importer. There is no obvious pattern of autocorrelation observed. For corn, in 5 out of 8 countries we reject this null hypothesis at the 5% significance level. For wheat, in 7 out of 7 countries we reject this null hypothesis at the 5% significance level. For soybeans, in 4 out of 6 countries we reject this null hypothesis at the 5% significance level.

Same as the results of PTE model, the assumption of nonautocorrelation is violated for Domestic Demand Elasticity (DDE) model as well. The OLS estimator will be unbiased but inefficient, with the true variance of the estimators being underestimated. I test this DDE model again by using the Restricted Maximum Likelihood (REML) estimator (Greene, 2004, p. 527 and 649). I report preferred DDE estimates for corn, wheat, and soybeans in Tables 4.7, 4.8, and 4.9, respectively. The estimates of the key coefficients do not in general differ very much from the OLS estimates.

Table 4.4 Diagnostic Tests for Corn

Test:	Breusch-Pagan	Breusch-Godfrey without *TREND*	Breusch-Godfrey with *Price of SBS* and*TREND*
Null hyp:	Homoscedasticity	No autocorrelation up to order 1 AR(1)	No autocorrelation up to order 1 AR(1)
Algeria	0.035**	0.217	0.215
Brazil	0.111	0.065*	0.386
China	0.220	0.001***	0.001***
Egypt	0.043**	0.002***	0.004***
India	0.164	0.980	0.980
Japan	0.011**	<0.001***	<0.001***
Japan†	0.959	0.508	0.350
Korea	0.598	0.367	0.397
Mexico	0.015**	<0.001***	0.001***

Notes: All values are *p*-values. †: These prices are collected from Japan Customs, from 1994 to 2007.
*denotes statistical significance at the 0.10 level.
** denotes statistical significance at the 0.05 level.
*** denotes statistical significance at the 0.01 level.

Table 4.5 Diagnostic Tests for Wheat

Test:	Breusch-Pagan	Breusch-Godfrey without *TREND*	Breusch-Godfrey with *Price of SBS* and *TREND*
Null hyp:	Homoscedasticity	No autocorrelation up to order 1 AR(1)	No autocorrelation up to order 1 AR(1)
Algeria	0.145	0.008***	0.001***
Brazil	0.073*	0.003***	0.008***
China	0.134	0.015**	0.015**
Egypt	0.535	0.002***	0.013**
Japan	0.128	<0.001***	<0.001***
Japan†	0.760	0.023**	0.639
Korea	0.594	0.031**	0.042**
Mexico	0.081	0.007***	0.016**

Notes: All values are *p*-values. †: These prices are collected from Japan Customs, from 1994 to 2007.
*denotes statistical significance at the 0.10 level.
** denotes statistical significance at the 0.05 level.
*** denotes statistical significance at the 0.01 level.

Table 4.6 Diagnostic Tests for Soybeans

Test:	Breusch-Pagan	Breusch-Godfrey without *TREND*	Breusch-Godfrey with *TREND*
Null hyp:	Homoscedasticity	No autocorrelation up to order 1 AR(1)	No autocorrelation up to order 1 AR(1)
Brazil	0.326	0.395	0.530
China	0.196	0.007***	0.027**
Egypt	0.415	0.000***	0.000***
Indonesia	0.010**	0.948	0.948
Japan	0.012**	<0.001***	<0.001***
Japan†	0.509	0.016**	0.076*
Mexico	0.086*	0.020**	0.014**

Notes: All values are *p*-values. †: These prices are collected from Japan Customs, from 1994 to 2007.
*denotes statistical significance at the 0.10 level.
** denotes statistical significance at the 0.05 level.
*** denotes statistical significance at the 0.01 level.

Table 4.7 Preferred Domestic Demand Elasticities for corn

Importers	δ_0 (intercept)	δ_1 (corn price)	δ_2 (Per cap income)	δ_3 (population)
Algeria	3.272**	-0.731**	0.312	0.919**
	(1.378)	(0.318)	(0.280)	(0.144)
Brazil	9.213***	-0.073*	-0.278	0.478***
	(0.706)	(0.040)	(0.283)	(0.165)
China	10.134***	-0.002	0.235**	0.120
	(0.253)	(0.016)	(0.097)	(0.147)
Egypt	6.356***	-0.205**	0.302***	0.252***
	(0.594)	(0.096)	(0.069)	(0.044)
India	7.744***	-0.003	0.414***	-0.098
	(0.125)	(0.068)	(0.065)	(0.055)
Japan	9.727***	-0.073	-0.314**	0.385***
	(0.477)	(0.058)	(0.116)	(0.063)
Korea	6.298***	-0.527***	0.011	0.621***
	(0.610)	(0.164)	(0.097)	(0.089)
Mexico	6.498***	-0.399***	0.643***	0.033
	(0.729)	(0.116)	(0.272)	(0.124)

Notes: Time series: 1976-2007. Standard error is in parenthesis. Dependent variable: Domestic consumption of corn at time *t* of importer *i*'s. Explanatory variable are the per capita income, population of county *i* and wheat prices.
*denotes statistical significance at the 0.10 level.
** denotes statistical significance at the 0.05 level.
*** denotes statistical significance at the 0.01 level.

Table 4.8 Preferred Domestic Demand Elasticities for wheat

Importers	δ_0 (intercept)	δ_1 (Wheat price)	δ_2 (Per cap income)	δ_3 (population)
Brazil	8.168***	-0.023	-0.002	0.322***
	(0.507)	(0.091)	(0.121)	(0.106)
China	9.793***	-0.011	0.072	0.367***
	(0.535)	(0.039)	(0.083)	(0.079)
Egypt	6.699	-0.136***	0.041	0.488***
	(0.240)	(0.031)	(0.157)	(0.041)
Japan	8.187***	-0.027	0.091*	-0.078
	(0.237)	(0.061)	(0.053)	(0.051)
Korea	10.483***	-1.236***	0.439	-0.060
	(1.088)	(0.369)	(0.283)	(0.464)
Mexico	6.930***	-0.094***	0.163***	0.219***
	(0.304)	(0.034)	(0.050)	(0.035)

Notes: Time series: 1971-2007. Standard error is in parenthesis. Dependent variable: Domestic consumption of wheat at time *t* of importer *i*'s. Explanatory variable are the per capita income, population of county *i*. and corn prices.

*denotes statistical significance at the 0.10 level.

** denotes statistical significance at the 0.05 level.

*** denotes statistical significance at the 0.01 level.

Table 4.9 Preferred Domestic Demand Elasticities for soybeans

Importers	δ_0 (intercept)	δ_1 (Soybeans price)	δ_2 (Per cap income)	δ_3 (population)
Brazil	4.719***	-0.040	0.119**	0.804***
	(0.335)	(0.057)	(0.042)	(0.052)
China	2.414	-0.025	0.601	0.947
	(1221.34)	(0.491)	(0.639)	(0.772)
Japan	13.022***	-0.115	-1.201**	0.102
	(2.266)	(0.424)	(0.424)	(0.038)
Mexico	1.241	-0.007	0.312*	0.953***
	(1.013)	(0.040)	(0.196)	(0.198)

Notes: Time series: 1968-2007. Standard error is in parenthesis. †: These prices are collected from Japan Customs, from 1994 to 2007. All prices are divided by GDP deflator. Dependent variable: Domestic consumption of wheat at time *t* of importer *i*'s. Explanatory variable are the per capita income, population of county *i* and wheat prices.
*denotes statistical significance at the 0.10 level.
** denotes statistical significance at the 0.05 level.
*** denotes statistical significance at the 0.01 level.

4.4. Estimated Domestic Demand Elasticities

In general the regressions perform well, with *R*-squares that can be quite high. The estimated coefficients for the demand model are somewhat sensitive to the set of variables change included on the right hand side. Korea has the most elastic domestic demand elasticity, which is -1.236 for wheat (Table 4.8). At times, I get an unexpected sign for some of the elasticity estimates. The estimation results indicate that demand for grains and oilseeds in most countries is fairly inelastic. This is in line with what we might expect for grains and oilseeds. They are not luxury goods and are generally used as an input into some other product.

5. ESTIMATION OF DOMESTIC SUPPLY ELASTICITIES

5.1. Model Description

Besides price transmission elasticity and domestic demand elasticity, another important component of the excess demand elasticity is the supply elasticity within importing countries (E_{si}). To estimate this I need to specify a supply function for each importer i. An important aspect of supply response in agriculture is the characterization of producer price expectations. For all of the commodities considered, there is a lag between when producers make planting decisions, and what the realized price for that year is. I follow the approach of Sadoulet and de Janvry (1995) and model price expectations as a naïve, one-period lag process. I estimate the following logarithmic model for a given grain:

$$(5.1) \qquad \ln Q_s^t = \alpha_0 + \alpha_1 \ln Q_s^{t-1} + \alpha_2 \ln p^{t-1} + \sum_{j=3}^{n} \alpha_j \ln Z_j^{t-1} + \varepsilon^t ,$$

where the α 's are parameters to be estimated, Q_{si}^{t-1} is grain output at time $t-1$, p^{t-1} is the lagged producer price, and Z_j^{t-1} are additional potential explanatory variables such as changes in area, prices of alternative commodities to produce, input costs or factor endowments, yield, weather, technology, policy. I have suppressed the importer index i for notational simplicity. The parameter α_2 is the short-run elasticity of supply response to last period's price change (Sadoulet and de Janvry, 1995). The long-run elasticity of supply response is calculated as $\alpha_2 /(1-\alpha_1)$. Both of them should be positive. Properties of the error term (ε^t) are assumed to be consistent with the classical linear regression model, but will be tested and discussed further down below.

5.2. Data Description for Domestic Supply Elasticity

Data for domestic supply elasticity estimation are mainly taken from United States Department of Agriculture Foreign Agricultural Service (USDA) PSDonline, USDA GATS, and FAOSTAT. I estimate domestic supply elasticities for the major importers. In the case of corn these are Brazil, China, Egypt, India, Japan, Korea, and Mexico. In the case of wheat the major importers are: Brazil, China, Egypt, Japan, Korea, and Mexico. In the case of soybeans the major importers are: Brazil, China, France, Italy, Japan, Korea, Mexico, and Turkey. Details are listed in the following Table 5.1-5.3. There are seven columns in each Table, which are variables, description, source, mean, min, max, and count respectively.

Table 5.1 Descriptive Statistics of Variables for Corn Domestic Supply Model

Variables	Description	Source	Mean	Min	Max	Count
$Q^t_{Alegeria}$	Annual domestic supply of corn at time *t* (1000 MT)	D	1.76	1	8	34
Q^t_{Brazil}	Annual domestic supply of corn at time *t* (1000 MT)	D	3136	1357	58600	34
Q^t_{China}	Annual domestic supply of corn at time *t* (1000 MT)	D	9896	4816	16590	34
Q^t_{Egypt}	Annual domestic supply of corn at time *t* (1000 MT)	D	476	271	630	34
Q^t_{France}	Annual domestic supply of corn at time *t* (1000 MT)	F	14715	11991	16440	16
Q^t_{India}	Annual domestic supply of corn at time *t* (1000 MT)	D	1026	560	1896	34
Q^t_{Italy}	Annual domestic supply of corn at time *t* (1000 MT)	F	9449	7394	11368	16
Q^t_{Japan}	Annual domestic supply of corn at time *t* (1000 MT)	D	238	1	11	34
Q^t_{Korea}	Annual domestic supply of corn at time *t* (1000 MT)	D	9526	57	154	34
Q^t_{Mexico}	Annual domestic supply of corn at time *t* (1000 MT)	D	1547	700	2423	34
$P^t_{Algeria}$	Unit value, annual free alongside ship price (current	A	112	70	164	33
P^t_{Brazil}	Unit value, annual free alongside ship price (current	A	136	83	353	26
P^t_{China}	Unit value, annual free alongside ship price (current	A	158	98	597	25
P^t_{Egypt}	Unit value, annual free alongside ship price (current	A	115	77	165	33
p^t_{France}	FAO producer price ((US $/tone)	F	145	95	246	16
P^t_{India}	Unit value, annual free alongside ship price (current	A	153	94	241	15
P^t_{Italy}	FAO producer price ((US $/tone)	F	186	157	269	16
P^t_{Japan}	Unit value, annual free alongside ship price (current	A	117	79	176	33
p^t_{Japan}	Annual Corn average price (current $/MT)	C	166	141	399	16
P^t_{Korea}	Unit value, annual free alongside ship price (current	A	119	78	180	33
P^t_{Mexico}	Unit value, annual free alongside ship price (current	A	120	84	182	33

Notes: Time series: 1976-2007. A refers to the USDA GATS, C refers to Japan Customs, 1994-2007.D refers to the USDA PSDonline F refers to FAOSTAT.

Table 5.2 Descriptive Statistics of Variables for Wheat Domestic Supply Model

Variables	Description	Source	Mean	Min	Max	Count
$Q^{t}_{Alegeria}$	Annual domestic supply of wheat at time *t* (1000 MT)	D	1535	615	2980	38
Q^{t}_{Brazil}	Annual domestic supply of wheat at time *t* (1000 MT)	D	3158	694	6000	38
Q^{t}_{China}	Annual domestic supply of wheat at time *t* (1000 MT)	D	9354	55210	12329	38
Q^{t}_{Egypt}	Annual domestic supply of wheat at time *t* (1000 MT)	D	4089	1616	8275	38
Q^{t}_{France}	Annual domestic supply of wheat at time *t* (1000 MT)	F	34550	29209	39809	16
Q^{t}_{Italy}	Annual domestic supply of wheat at time *t* (1000 MT)	F	7656	6229	8938	16
Q^{t}_{Japan}	Annual domestic supply of wheat at time *t* (1000 MT)	D	64442	202	1021	38
Q^{t}_{Korea}	Annual domestic supply of wheat at time *t* (1000 MT)	D	30	1	149	38
Q^{t}_{Mexico}	Annual domestic supply of wheat at time *t* (1000 MT)	D	3240	1700	4200	38
$P^{t}_{Algeria}$	Unit value, annual free alongside ship price (current	A	157	60	338	38
P^{t}_{Brazil}	Unit value, annual free alongside ship price (current	A	148	55	332	37
P^{t}_{China}	Unit value, annual free alongside ship price (current	A	151	62	381	34
P^{t}_{Egypt}	Unit value, annual free alongside ship price (current	A	143	96	285	37
P^{t}_{France}	FAO producer price ((US $/tone)	F	137	94	203	16
P^{t}_{Italy}	FAO producer price ((US $/tone)	F	211	144	326	16
P^{t}_{Japnan}	Unit value, annual free alongside ship price (current	A	164	57	440	38
P^{t}_{Japnan}	Annual 1001 wheat average price (current $/MT)	C	209	164	304	14
P^{t}_{Korea}	Unit value, annual free alongside ship price (current	A	155	57	401	38
P^{t}_{Mexico}	Unit value, annual free alongside ship price (current	A	155	64	370	38

Notes: Time series: 1971-2008. A refers to the USDA GATS, C refers to Japan Customs, 1994-2007. D refers to PSDOnline. F refers to FAOSTAT.

Table 5.3 Descriptive Statistics of Variables for Soybeans Domestic Supply Model

Variables	Description	Source	Mean	Min	Max	Count
Q^t_{Brazil}	Annual domestic supply of soybeans at time *t* (1000 MT)	D	4027	280	6160	23
Q^t_{China}	Annual domestic supply of soybeans at time *t* (1000 MT)	D	1628	137	7314	23
Q^t_{Egypt}	Annual domestic supply of soybeans at time *t* (1000 MT)	D	46	5	224	23
Q^t_{Japan}	Annual domestic supply of soybeans at time *t* (1000 MT)	D	610	357	770	23
Q^t_{Italy}	Annual domestic supply of soybeans at time *t* (1000 MT)	D	248	111	330	23
Q^t_{Mexico}	Annual domestic supply of soybeans at time *t* (1000 MT)	D	431	44	939	23
Q^t_{Turkey}	Annual domestic supply of soybeans at time *t* (1000 MT)	D	31	8	25	23
P^t_{Brazil}	Unit value, annual free alongside ship price (current $/MT)	A	212	118	303	27
P^t_{China}	Unit value, annual free alongside ship price (current $/MT)	A	258	187	526	28
P^t_{Egypt}	Unit value, annual free alongside ship price (current $/MT)	A	248	177	322	28
$P^t_{Indonesia}$	Unit value, annual free alongside ship price (current $/MT)	A	246	156	327	33
P^t_{Japnan}	Unit value, annual free alongside ship price (current $/MT)	A	233	97	334	41
P^t_{Mexico}	Unit value, annual free alongside ship price (current $/MT)	A	235	104	329	41
p^t_{Turkey}	Unit value, annual free alongside ship (current $/MT)	A	4.413	3.322	5.799	17

Notes: Time series: 1968-2007. A refers to the USDA GATS; C refers to the USDA PSDonline.

5.3. Violations of the Classical Linear Regression Model

In this section I will test whether the properties of the error term conform to the standard linear regression model. In particular, I test for nonstationarity of the data, heteroscedasticity, and autocorrelation.

Nonstationarity: In the previous chapter on price transmission elasticities, I already tested for nonstationarity for the price variables that we use, once again, in this chapter. In general the deflated price series were found to be stationary, so we do not make any adjustments here.

Heteroscedasticity: likewise, I use the Breusch-Pagan test to detect whether the estimated variance of the error terms are dependent on the values of the independent variables. For corn, in 1 out of 8 countries I reject this null hypothesis at the 5% significance level. For wheat, in 0 out of 7 countries I reject this null hypothesis at the 5% significance level. For soybeans, in 1out of 7 countries I reject this null hypothesis at the 5% significance level.

Autocorrelation: Likewise, I carry out the Breusch-Godfrey serial correlation LM test. For corn, in 2 out of 8 countries we reject this null hypothesis at the 5% significance level. For wheat, in 2 out of 7 countries we reject this null hypothesis at the 5% significance level. For soybeans, in 0 out of 7 countries we reject this null hypothesis at the 5% significance level. In these cases, the assumption of nonautocorrelation is not violated for Domestic Supply Elasticity (DSE) model.

Identification problem: The problem is that when looking at market price and quantity data, it is difficult to identify whether a change represents shifts in the demand curve versus shifts in the supply curve. Ideally I would estimate supply and demand behavior as a system of simultaneous equations. However, because of data constraints, this is not feasible for me. The consumer price data that I have for consumer demand model estimation is on a monthly basis. The producer price data that I have for supply model estimation is on an annual basis. Therefore demand and supply equations must be estimated as single equations for individual countries.

Endogeneity of right-hand side variables: Q_s^{t-1} and p^{t-1} are potentially endogenous. Since they are lagged, this should not be a problem if there is no time series autocorrelation, however, since they can be taken as exogenous (no correlation between them and the disturbance term). I don't need to instrument for Q_s^{t-1} and p^{t-1} because they can be taken to be exogenous right-hand side variables.

Table 5.4 Diagnostic Tests for Corn

Test:	Breusch-Pagan	Breusch-Godfrey *(with trend and lagged wheat price)*
Null hyp:	Homoscedasticity	No autocorrelation up to order 1 AR(1)
Algeria	0.759	0.085*
Brazil	0.831	0.183
China	0.713	0.299
Egypt	0.894	0.129
France	0.099*	0.328
India	0.255	0.117
Italy	0.581	0.910
Japan	0.053*	0.219
Japan†	0.008***	0.006***
Korea	0.799	0.471
Mexico	0.915	0.062*

Notes: All values are *p*-values.
*denotes statistical significance at the 0.10 level.
** denotes statistical significance at the 0.05 level.
*** denotes statistical significance at the 0.01 level.

Table 5.5 Diagnostic Tests for Wheat

Test:	Breusch-Pagan	Breusch-Godfrey *(with trend and lagged corn price)*
Null hyp:	Homoscedasticity	No autocorrelation up to order 1 AR(1)
Brazil	0.312	0.079*
China	0.378	0.594
Egypt	0.144	0.178
France	0.076*	0.708
Italy	0.649	0.829
Japan	0.270	0.157
Japan†	0.247	0.512
Korea	0.795	0.519
Mexico	0.179	0.905

Notes: All values are *p*-values.
*denotes statistical significance at the 0.10 level.
** denotes statistical significance at the 0.05 level.
*** denotes statistical significance at the 0.01 level

Table 5.6 Diagnostic Tests for Soybeans

Test:	Breusch-Pagan	Breusch-Godfrey
Null hyp:	Homoscedasticity	No autocorrelation up to order 1 AR(1)
Brazil	0.409	0.699
China	0.200	0.396
Egypt	0.344	0.301
France	0.888	0.163
Italy	0.263	0.426
Japan	0.530	0.882
Japan†	0.447	0.971
Mexico	0.047**	0.115
Turkey	0.320	0.433

Notes: All values are *p*-values.
*denotes statistical significance at the 0.10 level.
** denotes statistical significance at the 0.05 level.
*** denotes statistical significance at the 0.01 level

Table 5.7 Preferred Domestic Supply Elasticities for corn

Importers	α_0 (intercept)	α_1 (lagged domestic corn production)	α_2 (lagged corn price)	R^2
Brazil	4.028***	0.595***	-0.023	0.841
	(1.093)	(0.116)	(0.062)	
China	6.039***	0.402*	0.061	0.910
	(1.989)	(0.197)	(0.027)	
Egypt	6.745***	0.202	0.068*	0.968
	(2.040)	(0.235)	(0.035)	
India	0.737	0.619*	1.528*	0.931
	(3.301)	(0.312)	(0.809)	
Japan	2.258***	0.117	0.015	0.462
	(0.044)	(0.158)	(0.031)	
Korea	2.287***	0.667***	0.038	0.611
	(0.518)	(0.095)	(0.034)	

Notes: Standard error is in parenthesis. Time series is 1976-2007. †: data are collected from Japan Customs, annual, started from 1995to 2008.Dependent variable: Domestic output of corn at time *t* of importer *i*'s. Explanatory variables are the output of corn in country *i* at time *t-1*, annual US producer price at time *t-1* and additional potential variable technology trend.

*denotes statistical significance at the 0.10 level.

** denotes statistical significance at the 0.05 level.

*** denotes statistical significance at the 0.01 level.

Table 5.8 Preferred Domestic Supply Elasticities for wheat

Importers	α_0 (intercept)	α_1 (lagged domestic wheat production)	α_2 (lagged wheat price)	R^2
Brazil	8.125***	-0.254***	1.933	0.621
	(1.773)	(0.265)	(0.540)	
China	4.247*	0.598***	0.222**	0.910
	(1.990)	(0.175)	(0.093)	
Egypt	1.067	0.874***	0.034	0.774
	(1.205)	(0.163)	(0.261)	
India	1.941*	0.742***	0.283*	0.931
	(0.100)	(0.123)	(0.103)	
Japan	-0.556	0.740***	0.964*	0.843
	(0.856)	(0.129)	(0.335)	
Korea	-10.083	0.317***	5.382	0.253
	(7.535)	(0.241)	(3.517)	
Mexico	5.445***	0.300	0.225	0.450
	(1.707)	(0.217)	(0.115)	

Notes: Standard error is in parenthesis. Time series is 1971-2008. started from 1995 to 2008. Dependent variable: Domestic output of wheat at time *t* of importer *i*'s. Explanatory variable are the output of wheat in country *i* at time *t-1*, and its unit value in time *t-1*.
*denotes statistical significance at the 0.10 level.
** denotes statistical significance at the 0.05 level.
*** denotes statistical significance at the 0.01 level.

Table 5.9 Preferred Domestic Supply Elasticities for soybeans

Importers	α_0 (intercept)	α_1 (lagged domestic soybeans production)	α_2 (lagged soybeans price)	R^2
Brazil	6.770***	0.223*	0.037	0.524
	(0.001)	(0.024)	(0.345)	
China	-0.100	0.991***	0.137	0.988
	(0.540)	(0.001)	(0.242)	
Egypt	-2.211*	0.368*	1.592*	0.897
	(0.952)	(0.248)	(0.546)	
France	3.102	0.804***	0.335	0.815
	(0.108)	(0.001)	(0.573)	
Italy	1.737*	0.675**	0.333	0.643
	(0.071)	(0.003)	(0.769)	
Japan	1.219***	0.812***	-0.008	0.878
	(0.001)	(0.001)	(0.830)	
Mexico	0.537*	0.887***	0.139*	0.937
	(0.027)	(0.001)	(0.016)	

Notes: Standard error is in parenthesis. Time series is 1968-2007. Dependent variable: Domestic output of soybeans at time *t* of importer *i'*s. Explanatory variables are the output of soybeans in country *i* at time *t-1*, unit value in time *t-1* .
*denotes statistical significance at the 0.10 level.
** denotes statistical significance at the 0.05 level.
*** denotes statistical significance at the 0.01 level.

5.4. Estimated Short-run Domestic Supply Elasticities

The supply response model is estimated with annual observations in major importing countries on corn, wheat, and soybeans. Based upon the results of diagnostic tests, the OLS estimator is fine for most of our applications and is reported most of the time, along with REML results in some cases. Results are reported in Tables 5.7-5.9.

The coefficient of interest is α_2, which is on the natural logarithm of lagged own price in (5.1). It varies as the set of right-hand side variables changes. Looking across the specifications, the short-run elasticity of supply for corn ranges from 0.0 to 1.528 for the following countries: Egypt, China, Japan, Korea, Mexico and India (Table 5.7).

The standard error of the estimator is reported in the tables below the coefficient in parenthesis. Despite the generally positive results mentioned above, the coefficient of interest ($\hat{\alpha}_2$) is not always statistically different from zero at conventional levels of significance. Consider the case of Japan, for example, for which I have two estimates based upon two different types of price data. When I use the U.S.-reported unit value-free alongside ship prices, the OLS estimate ($\hat{\alpha}_2$) is -0.078, which is the unexpected sign. When I use the annual corn average price (current $/MT) collected from Japan Customs, the estimate is 0.019. This is now the right sign, perhaps because the latter data are in general more informative about actual prices. In both cases, however, the coefficient cannot be said to be statistically different than zero at any conventional significance level. Possible reasons include the following: short length of the time series, and the very tiny production of corn in Japan, as well as in many other countries in this sample.

Japan's 0.015 coefficient for corn can also be interpreted as an elasticity of supply response. It corresponds to short-run supply response, and in this case implies that a 1% increase in last period's corn price is associated with a 0.015% increase in area planted in the near future. Looking at other examples in Table 5.7, India has an estimated $\hat{\alpha}_2$ coefficient of 1.528. This is the highest level of supply response in this table. It implies that there will be a 1.528% increase in area corn planted in short-run as a 1% increase in last period's corn price.

To see how adding other variables may change the results, Table 5.8 reports the results for wheat domestic supply elasticities. In Table 5.8, three out of seven of the $\hat{\alpha}_2$ estimates lie between 0.0 to 0.4. Many of the rest of the coefficients in this table are again not statistically different from zero at conventional levels of statistical significance.

The results for the models without lagged production on the right-hand side do not deviate in meaningful ways and are not described here. When possible I try to account for relevant policies on the right-hand side. For example, I account for the potential impact of the North American Free Trade Agreement (NAFTA), using a dummy variable, in the case of Mexico. Since NAFTA came into effect on January 1, 1994, U.S. corn exports to Mexico have almost doubled, e.g., they were six million metric tons in 2002. Another variation I tried was to add the price of a substitute commodity, such as lagged wheat price, and trend variables representing changes in technology over time. Added these to the model in some cases improve the results, e.g., in terms of R square.

In addition, different types of prices can be used. The above results make use of the price that a particular country paid for grain at the U.S. port, aggregated to an annual basis. It therefore may be a lower price than actual, local producer prices. I also tried using FAO producer prices on the right-hand side as these are available. So far I have been describing the results for corn and wheat. Analogous results for soybeans are reported in Tables 5.9. Instead of discussing those in detail right now, I will discussion of which estimates I actually use later on for excess demand elasticity calculation in chapter 6. Continued discussion of these results is in that chapter.

6. ELASTICITIES OF EXCESS EXPORT DEMAND

6.1. Overview of Calculations

In this chapter I now make use of the price transmission, demand, and supply elasticity estimates of the previous chapters to calculate the excess demand elasticity of U.S. crops exports that was given in Chapter 2. In particular, I plug the estimated values into equation (2.5) in order to calculate a unique excess demand elasticity faced by the U.S. for each of: corn, wheat, and soybeans.

According to the estimation of short-run price transmission, domestic demand and supply elasticities discussed in chapters 3-5, I list the preferred estimates for corn, wheat and soybeans in Table 6.1-6.3 respectively. These estimates are preferred in the sense that they are most consistent with what has appeared in relevant previous studies. In addition, they are what economic theory would predict. If I get both negative and positive supply response elasticities across different specifications, for example, I tend to prefer the one that is positive since this makes more sense from theory. All else the same, I tend to prefer the estimate that is based on an estimator that is most appropriate according to tests done in each chapter.

I calculate the short-run domestic supply elasticities based upon the preferred short-run elasticity of supply response ($\hat{\alpha}_2$) and the short-run price transmission elasticity ($\hat{\beta}_2$). I calculate the long-run domestic supply elasticities based upon the long-run elasticity of supply response ($\hat{\alpha}_2/(1-\hat{\alpha}_1)$) and the long-run price transmission elasticity is taken to be the upper bound on the short-run value ($\hat{\beta}_2$), which is one. The domestic demand elasticities do not vary across short- and long-run specifications because lags are less important in this regard.

An important part of estimating equation (2.5) is to have the shares data, domestic total production and consumption share of U.S. total export to all of the major importers estimated in the previous chapters. I collect this information mainly from the USDA GATS, USDA PSDonline, and the FAOSTAT. Lastly, I calculate the elasticities of excess export demand for corn, wheat, and soybeans individually by using the estimation results above, which are presented in the last row of Tables 6.4-6.6.

Table 6.1 Preferred Estimates of Short-Run Price Transmission Elasticities

	Corn	Wheat	Soybeans
Algeria	0.499	0.278	--
Brazil	0.252	0.348	0.230
China	0.283	0.087	0.810
Egypt	0.452	0.237	--
India	0.165	0.225	--
Indonesia	--	--	0.516
Italy	0.674	0.382	0.317
Japan	0.379	0.205	0.389
Korea	0.455	0.312	0.502
Mexico	0.274	0.315	0.255
Spain	0.721	0.224	0.688
Turkey	--	--	0.450

Note: Chapter 3 describes how these values were estimated. --: Not available.
Long run price transmission elasticities are assumed to be one.

Table 6.2 Preferred Estimates of DomesticDemand Elasticities

	Corn	Wheat	Soybeans
Algeria	-0.731	0.010	--
Brazil	-0.073	-0.023	-0.040
China	-0.002	-0.011	-0.025
Egypt	-0.205	-0.136	-0.243
India	-0.003	--	--
Japan	-0.073	-0.027	-0.115
Korea	-0.527	-1.236	--
Mexico	-0.399	-0.094	-0.007

Note: Chapter 4 describes how these values were estimated. --: Not available.

Table 6.3 Preferred Short and Long-run Domestic Supply Elasticities

	Corn		Wheat		Soybeans	
Importers	Short run	Long run	Short run	Long run	Short run	Long run
Brazil	-0.023	-0.103	1.933	2.894	0.037	4.111
China	0.061	0.782	0.222	0.714	0.137	1.713
Egypt	0.068	1.814	0.034	-0.872	1.592	1.596
France	--	--	--	--	0.335	1.709
India	1.528	5.922	--	--	--	--
Italy	--	--	--	--	0.333	1.129
Japan	0.015	0.031	0.964	18.538	-0.008	-0.043
Korea	0.038	0.144	5.382	36.863	--	--
Mexico	-0.019	-0.218	0.225	0.616	0.139	1.230
Turkey	--	--	--	--	-0.057	-0.206

Note: Chapter 5 describes how these values were estimated. --: Not available.

Table 6.4 Elasticities of Excess Demand for Corn Export

	Domestic demand elasticity	Supply elasticity		Price transmission elasticity		Domestic production divided by total U.S. corn exports	Domestic consumption divided by total U.S. corn exports	Excess export demand elasticity	
		Short run	Long run	Short run	Long run			Short run	Long run
	E_{di}	E_{si}		E_{pi}		$\frac{Q_{si}}{Q_{ef}}$	$\frac{Q_{di}}{Q_{ef}}$	E_{ef}	
Algeria	-0.731	0.632	0.797	0.499	1	0.0000405	0.214	-0.008	-0.016
Brazil	-0.073	-0.023	-0.103	0.252	1	0.621	0.601	-0.008	0.020
China	-0.002	0.061	0.782	0.283	1	1.950	1.855	-0.035	-1.529
Egypt	-0.205	0.078	1.814	0.452	1	0.096	0.149	-0.017	-0.205
India	-0.003	1.528	5.922	0.165	1	0.202	0.197	-0.051	-1.196
Japan	-0.078	0.015	0.031	0.379	1	0.00006	0.312	-0.004	-0.024
Korea	-0.527	0.038	0.144	0.455	1	0.002	0.123	-0.029	-0.065
Mexico	-0.399	-0.019	-0.218	0.274	1	0.309	0.384	-0.040	-0.086
Total	$E_{ef} = \sum_i E_{pi}\left[E_{di}\frac{Q_{di}}{Q_{ef}} - E_{si}\frac{Q_{si}}{Q_{ef}}\right]$							**Short run: -0.198**	**Long run: -3.101**

Table 6.5 Elasticities of Excess Demand for Wheat Export

	Domestic demand elasticity E_{di}	Supply elasticity E_{si}		Price transmission elasticity E_{pi}		Domestic production divided by total U.S. wheat exports $\frac{Q_{si}}{Q_{ef}}$	Domestic consumption divided by total U.S. wheat exports $\frac{Q_{di}}{Q_{ef}}$	Excess export demand elasticity E_{ef}	
		Short run	Long run	Short run	Long run			Short run	Long run
Algeria	-0.010	0.482	0.468	0.278	1	0.048	0.162	-0.007	-0.024
Brazil	-0.024	1.933	2.894	0.348	1	0.105	0.252	-0.073	-0.310
China	-0.011	0.222	0.714	0.087	1	2.867	3.015	-0.058	-0.078
Japan	-0.027	0.964	18.538	0.205	1	0.021	0.189	-0.005	-0.403
Korea	-1.236	5.382	36.863	0.312	1	0.001	0.099	-0.039	-0.146
Mexico	-0.094	0.225	0.616	0.315	1	0.106	0.149	-0.012	-0.079
Total	$E_{ef} = \sum_i E_{pi}\left[E_{di}\frac{Q_{di}}{Q_{ef}} - E_{si}\frac{Q_{si}}{Q_{ef}}\right]$							**Short run: -0.194** **Long run: -1.040**	

Table 6.6 Elasticities of Excess Demand for Soybeans Export

	Domestic demand elasticity E_{di}	Supply elasticity E_{si} Short run	Supply elasticity E_{si} Long run	Price transmission elasticity E_{pi} Short run	Price transmission elasticity E_{pi} Long run	Domestic production divided by total U.S. soybean exports $\frac{Q_{si}}{Q_{ef}}$	Domestic consumption divided by total U.S. soybean exports $\frac{Q_{di}}{Q_{ef}}$	Excess export demand elasticity E_{ef} Short run	Excess export demand elasticity E_{ef} Long run
Brazil	-0.041	0.037	0.053	0.230	1	4.968	3.410	-0.074	-0.403
China	-0.025	0.137	1.713	0.810	1	2.143	2.974	-0.298	-3.745
Japan	-0.115	-0.008	-0.043	0.389	1	0.756	0.769	-0.032	-0.024
Mexico	-0.007	0.139	1.230	0.735	1	0.539	0.539	-0.020	-0.667
Total	$E_{ef} = \sum_i E_{pi} \left[E_{di} \frac{Q_{di}}{Q_{ef}} - E_{si} \frac{Q_{si}}{Q_{ef}} \right]$							**Short run: -0.424**	**Long run: -4.791**

6.2 Comparison to Previous Studies

A good way to understand my estimates is to compare them to previous estimates in the literature. There are a wide range of elasticities reported in past studies (e.g., Gardiner and Dixit, 1987; Carter and Gardiner, 1988; Miller and Paarlberg, 2001). They vary by commodity, length of time frame, estimation technique, and the source of price data (e.g., farm price or export unit value). This makes it hard to make an exact type of comparison. I report a sample of previous estimates in Tables 6.7 to 6.9. These are representative of most previous studies.

The findings of previous studies for wheat excess demand elasticity are shown in Table 6.7. All of the researches listed in tables are using calculation method. Johnson (1977) was one of the earliest to estimate the price elasticity of demand for U.S. wheat exports using the calculation method. He finds a long run elasticity of export demand of -6.72 (Table 6.7). This is much more elastic than the -1.04 estimate that I found in the long run (Table 6.7). I believe that his estimate is more elastic because it is based on a very strong assumption, namely that there is perfect price transmission from the U.S. market to all foreign markets.

There are a number of reasons why there is not perfect price transmission, however, and why this is a potentially very erroneous assumption. For example, U.S.-foreign price linkages may be “sticky” due to the insulating effects of border policies, menu or catalog pricing (prices are not re-negotiated continuously), oligopoly market power, imperfections in future price markets, and imperfect exchange rate pass through (Krugman, 1987; Pick and Park, 1991, Pick, 1990; Kandilov, 2008).

Another reason why the Johnson (1977) is potentially less reliable is that it is based on identical domestic supply and domestic demand elasticities for all countries that import U.S. wheat. This is is a convenient simplification but has profound impact on the calculated elasticities and raise serious questions about their applicability to the real world. Furthermore, he did not point out the source of the supply and demand elasticities used in his calculation. They are educated guesses.

Table 6.7 Wheat Excess Demand Elasticity Comparison

		Elasticity	
Study	Period	Shortrun	Long run
Zheng (2010)	1971-2007	-0.194	-1.04
Johnson (1977)	1970 base	--	-6.72
Bredahl, et.al (1979)	1972/73-1975/76	--	-1.67
Paarlberg (1983)	1960-75	--	-1.82
Johnson et al.(1985)	1985	-0.16	“near 1.0”
Meyers and Helmar	1986	-0.11	--
Tyers and Anderson	1988	-1.00	-2.90
Miller and Paarlberg (2001)	1960-1999	--	-3.83
Miller and Paarlberg (2001)	1960-1984	-2.43	-2.33
Miller and Paarlberg (2001)	1985-1999	-1.65	-1.45

Source: Gardiner, W.H., and P.M. Dixit (1987). *Price Elasticity of Export Demand: Concepts and Estimates*. --: Not available.

Another study to which I can compare my results is Bredahl, Meyers, and Collins (1979). They find, for example, that the export demand elasticity for wheat is -1.67. They argued that Tweeten and Johnson did not sufficiently account for domestic and trade policies pursed by importing countries distorting the transmission of world prices into their domestic market (Gardiner and Dixit, 1987). In spite of their study improves on the Johnson and Tweeten studies, the price transmission elasticity was based on educated guess in their report, which is varied from zero (restricted trade) to 1 (free trade). Clearly, to more accurately measure how U.S. prices affect foreign prices, we should directly estimate price transmission elasticities by using statistical methods. My results are -0.19 and -1.04 for short- and long-run elasticities respectively, which is closest to the finding of Johnson (1985). In a different way to all of the previous studies, I estimate the price transmission, domestic demand and supply elasticities respectively using recent historical data, rather than educated guess.

Table 6.8 Corn Excess Demand Elasticity Comparison

Study	Period	Elasticity Short run	Long run
Zheng (2010)	1976-2007	-0.198	-3.101
Bredahl, Meyers, and Collins (1979)	1972/73-1975/76	--	-1.31
Chambers and Just (1981)	1969-1977	-0.47	-0.63

Source: Gardiner, W.H., and P.M. Dixit (1987). --: Not available.

Three studies for corn excess demand elasticity are reported in Table 6.8. Bredahl, Meyer, and Collins (1979) stated the corn elasticites varied from -0.09 for the most restrictive case to -3.13 for the free trade case. The estimate thought to be the closest to the real world for corn was -1.31. Gardiner (1986) obtained a long run export demand elasticity for corn that was in the elastic range (-1.18), which was calculated from price transmission, demand, and supply elasticities with the period 1967-1980. My results are much larger than theirs, which are -0.198 and -3.101 for short- and long-run elascitcies respectively.

Lastly, only a few studies in this survey obtained elasticity estimates for soybeans and their products by the calculation method, which are listed in Table 6.9. Bredahl, Meyer, and Collins (1979) used Johnson's domestic supply and demand elasticities for importing countries to compute long run U.S. soybean export demand elasticities under various trade policy environments (Gardiner and Dixit, 1987). Estimates ranged from -0.39 to -1.12, and they picked the intermediate case value of -0.47, which is lower than the estimate obtained by Johnson (-2.8). The findings of Chambers and Just (1981), and Miller and Paarlberg (2001) are -0.29 and -1.27 respectively. Compared to their studies, mine is much larger. Short run export demand elasticity for soybeans is -0.525 and long run elasticity is -5.407.

Table 6.9 Soybean Excess Demand Elasticity Comparison

		Elasticity	
Study	Period	Short run	Long run
Zheng (2010)	1968-2007	-0.42	-4.80
Johnson (1977)	1970 base	--	-2.8
Bredahl, Meyers, and Collins (1979)	1972/73-1975/76	--	-0.47
Chambers and Just (1981)	1969-1977	-0.2	-0.29
Miller and Paarlberg (2001)	1964-1999	--	-1.27

Source: Gardiner, W.H., and P.M. Dixit (1987). --: Not available.

7. CONCLUSIONS

The objectives of this research were to improve upon existing formulations for estimating export demand for U.S. agricultural commodities, and to provide new estimates using updated data for the last two decades. The results of the analysis lead to several interesting conclusions which may shed light on the development of future policies directed towards U.S. export management on major crops.

In this study, I estimate the price elasticity of excess demand for U.S. corn, wheat, soybeans exports respectively. Firstly, I formulate an economic model of U.S. exports including country-specific, grain-specific price transmission elasticities, supply elasticities, and demand elasticities for each of the major importers of U.S. crops. In case of wheat, there are 10 major importers, in case of corn, there are 8 major importers, and in case of soybeans, there are 6 major importers. Different crop has different time series estimated. I use monthly data for estimating price transmission elasticity, and only annual time series data available for domestic demand and supply elasticities estimation. I then incorporate these estimates into an economic model of U.S. export markets to calculate the excess demand elasticities.

I estimate the short-run excess demand elasticity for U.S. wheat, corn and soybeans exports to be -0.194, -0.198, and -0.424, respectively. I estimate the long-run excess demand elasticity for U.S. wheat, corn and soybeans exports to be -1.040, -3.101 and -4.791, respectively. As expected these are each somewhat more elastic than the short run estimates. Overall, demand for U.S. corn and soybeans exports are fairly elastic over the long run (at least 4-6 years).

For those commodities with relatively elastic excess demand curves (corn and soybeans), U.S. exports will likely fall if the U.S. introduces policies that somehow end up raising commodity prices. Foreign buyers are more price sensitive and may switch to alternative suppliers. Rival suppliers may respond to the higher prices and increase their share of world markets. For those commodities having relatively inelastic excess demand (wheat), then the U.S. could use land retirement and stocks policies, for example, to raise commodity prices at little cost to export volume or market share.

It is important to point out some of the limitations of this study. Some of the time series data are unavailable for major importing countries, which might lead to an inaccurate estimate, since shorter estimation periods are used when data is unavailable. Another limitation of the study is that the excess demand elasticity does not take into account each possible importer of either corn, wheat, or soybeans. Even though some countries may be an important importer, they may not report all of the information that is necessary for calculating the underlying determinants in my model, including price transmission elasticities, domestic demand elasticities, and domestic supply elasticities. This might be viewed as a limitation, but it is important to emphasize that this should not necessarily bias the excess demand elasticities. The crops upon which they are based can be argued to be representative of all importers of a particular commodity.

Another potential limitations is that I have not estimated the foreign supply and demand elasticities using a simultaneous equations model that controls for endogeneity. I could also potentially estimate either the demand or supply models as systems as opposed to single equations.

REFERENCES

Abbott, P., 1979. "Modeling International Grain Trade with Government Controlled Markets." *American Journal of Agricultural Economics* 61:22-31.

Abbott, P., P. Paarlberg, and J. Sharples, 1986. "Targeted Agricultural Export Subsidies and Social Welfare." Purdue University Agricultural Economics Working Paper 86-4.

Bredahl, M.E., W.H. Meyers, and K.J. Collins. 1979. "The Elasticity of Foreign Demand for U.S. Agricultural Products: The Importance of the Price Transmission Elasticity." *American Journal of Agricultural Economics* 61(1):58-63.

Carter, C.A. and W.H. Gardiner, eds. 1988. *Elasticities in International Agricultural Trade.* Boulder: Westview Press.

Conforti, P. 2004. "Price Transmission in Selected Agricultural Markets." Commodities and Trade Policy Research Paper No. 7. Food and Agriculture Organization, Rome.

Gardiner, W.H., and P.M. Dixit. 1987. *Price Elasticity of Export Demand: Concepts and Estimates*. Washington DC: U.S. Department of Agriculture, ERS, Foreign Agricultural Economic Report No. 228, February.

Greene, W.H. 2004. *Econometric Analysis*. New York: Prentice-Hall.

Hill, R., W. Griffiths, and G. Lim. 2008. *Principles of Econometrics*. Hoboken, N.J.: John Wiley and Sons.

Holland, F.D., and J.A. Sharples. 1984. "World Wheat Trade: Implications for U.S. Wheat Exports." Staff Paper No. 84-20. Department of Agricultural Economics, Purdue University.

Johnson, P.R. 1977. "The Elasticity of Foreign Demand for U.S. Agricultural Products." *American Journal of Agricultural Economics* 59(4):735-736.

Johnson, S.R., A.W. Womack, W.H. Meyers, R.E. Young II and J. Brandt. 1985. "Options for the 1985 Farm Bill: An Analysis and Evaluation," FAPRI Report No. 1-85, Food and Ag. Policy Research Institute, University of Missouri-Columbia and Iowa State University.

Kandilov, I. 2008. "The Effects of Exchange Rate Volatility on Agricultural Trade." *American Journal of Agricultural Economics* 90:1028-1043.

Krugman, P. 1987. “Pricing to Market When the Exchange Rate Changes.” Ed. S. Arndt, and J. Richardson. Real-Financial Linkages Among Open Economies. Cambridge, MA, MIT Press, pp. 48-70.

Madsen, J.B. 1998. “Errors-in-variables, supply side effects, and price elasticities in foreign trade.” *Review of World Economics* 134(4):612-637.

Magee, S.P. “Prices, Incomes, and Foreign Trade: A Survey of Recent Economic Studies.” 1975. In: Kenen, P.B. (ed) *International Trade and Finance: Frontiers for Research*. Cambridge: Cambridge University Press. pp. 175-252.

Meyers, W.H. S. Devadoss, and M.D. Helmar. 1987. “Agricultural Trade Liberalization: Cross-Commodity and Cross-Country Impacts,” *Journal of Policy Modeling* 9(3):455-484.

Meyers, W.H. and M.D. Helmar. 1986. “Trade Implications of the Food Security Act of 1985,” Staff Report No. 86-SR4, Center for Agricultural and Rural Deevlpment, Iowa State University, February.

Miller, D.J., and P.L. Paarlberg (2001) “An Alternative Approach to Determining the Elasticity of Excess Demand Facing the United States.” Presented at 2001 AAEA meetings.

Orcutt, G.H. 1950. “Measurement of Price Elasticities in International Trade.” *Review of Economics and Statistics*. 32:117-132.

Pick, D. 1990. “Exchange Rate Risk and US Agricultural Trade Flows.” *American Journal of Agricultural Economics* 72:694-700.

Pick, D., and T. Park. 1991. “The Competitive Structure of U.S. Agricultural Exports.” *American Journal of Agricultural Economics* 73:133-141.

Sadoulet, Elisabeth and Janvry, Alain de. 1995. *Quantitative Development Policy Analysis*. Baltimore: The John Hopkins University Press.

Thursby, J.G. and M.C. Thursby. 1988. “Elasticities in International Trade: Theoretical and Methodlogical Issues.” In: Colin A. Carter and Walter H. Gardiner, eds. *Elasticities in International Agricultural Trade*. Boulder: Westview Press. pp. 17-52.

Tweeten, L. 1967. “The Demand for U.S. Farm Output.” *Food Research Institute Studies*

Tyers, R. and K. Anderson. 1988. “Imperfect Price Transmission and Implied Trade Elasticities in a Multi-commodity World.” In: C.A. Carter and W.H. Gardiner, eds. *Elasticities in International Agricultural Trade*. Boulder: Westview Press. pp. 255-295.

APPENDICES

APPENDIX

A1. Alternative Approach from Bredahl, Meyers, and Collins

Let the excess demand (imports) of an importing country be $Q_{mi} = Q_{di} - Q_{si}$. Let the excess supply (exports) of any exporting country except the U.S. be $Q_{xj} = Q_{sj} - Q_{dj}$. One way to state the demand for U.S. exports is in terms of these other exporters as well as the importers:

$$Q_{ef} = \sum_i Q_{mi} - \sum_j Q_{sj}.$$

The elasticity of export demand is found by taking the derivative with respect to p_{US}:

$$\frac{dQ_{ef}}{dp_{US}} = \sum_i \left[\frac{dQ_{mi}}{dp_i} \frac{dp_i}{dp_{US}} \right] - \sum_j \left[\frac{dQ_{sj}}{dp_j} \frac{dp_j}{dp_{US}} \right],$$

$$\frac{dQ_{ef}}{dp_{US}} \frac{p_{US}}{Q_{ef}} Q_{ef} = \sum_i \left[\frac{dp_i}{dp_{US}} \frac{p_{US}}{p_i} \frac{dQ_{mi}}{dp_i} \frac{p_i}{Q_{mi}} Q_{mi} \right] - \sum_j \left[\frac{dp_j}{dp_{US}} \frac{p_{US}}{p_j} \frac{dQ_{sj}}{dp_j} \frac{p_j}{Q_{sj}} Q_{sj} \right],$$

$$\frac{d\ln Q_{ef}}{d\ln p_{US}} = \sum_i \left[\frac{d\ln p_i}{d\ln p_{US}} \frac{d\ln Q_{mi}}{d\ln p_i} \frac{Q_{mi}}{Q_{ef}} \right] - \sum_j \left[\frac{d\ln p_j}{d\ln p_{US}} \frac{d\ln Q_{sj}}{d\ln p_j} \frac{Q_{sj}}{Q_{ef}} \right],$$

$$E_{ef} = \sum_i \left[E_{pi} E_{edi} \frac{Q_{mi}}{Q_{ef}} \right] - \sum_j \left[E_{pj} E_{esj} \frac{Q_{xj}}{Q_{ef}} \right],$$

where E_{edi} is the elasticity of excess demand in country *i*, and E_{esj} is the elasticity of excess supply in country *i*. The elasticity of excess demand of importers is:

$$E_{edi} = \left(E_{di} - E_{si} \right) \frac{Q_{di}}{Q_{mi}} + E_{si},$$

which is derived by taking the derivative of $Q_{mi} = Q_{di} - Q_{si}$ with respect to p_{US}.

Similarly, the elasticity of excess supply of exporters is:

$$E_{esj} = \left(E_{sj} - E_{dj}\right)\frac{Q_{dj}}{Q_{xj}} + E_{sj},$$

which is derived by taking the derivative of $Q_{xj} = Q_{sj} - Q_{dj}$ with respect to p_{US}. We can simplify by writing:

$$E_{ef} = \sum_i \left[E_{pi} \left(\left(E_{di} - E_{si}\right)\frac{Q_{di}}{Q_{mi}} + E_{si} \right)\frac{Q_{mi}}{Q_{ef}} \right] - \sum_j \left[E_{pj} \left(\left(E_{sj} - E_{dj}\right)\frac{Q_{dj}}{Q_{xj}} + E_{sj} \right)\frac{Q_{xj}}{Q_{ef}} \right]$$

$$E_{ef} = \sum_i \left[E_{pi} \left(\left(E_{di} - E_{si}\right)\frac{Q_{di}}{Q_{ef}} + E_{si}\,\frac{Q_{mi}}{Q_{ef}} \right) \right] - \sum_j \left[E_{pj} \left(\left(E_{sj} - E_{dj}\right)\frac{Q_{dj}}{Q_{ef}} + E_{sj}\,\frac{Q_{xj}}{Q_{ef}} \right) \right].$$

The elasticity of excess demand for U.S. agricultural commodities is based on the following for all countries *i* that import from the U.S. and all countries *j* that are alternative world suppliers: their supply and demand elasticities, the levels of domestic consumption relative to overall U.S. exports, net imports from the U.S. relative to overall U.S. exports, and the elasticity of price transmission from the U.S.

A2. GDP Deflator Conversion

A problem in deflating price series is that the GDP deflator that I use (University of Pennsylvania) is on an annual basis, while some of my price series on a monthly basis. I therefore need to convert the annual GDP deflator to a monthly GDP deflator. In this section I describe two potential ways to do this.

Let T_0 denote yearly GDP of year 0, T_1 and T_2 are yearly GDP of year1 and 2, respectively, and $T_{n,m}$ be monthly GDP of the *m*th month, year *n* (e.g. $T_{1,1}$: monthly GDP of 1st month (January), year 1). We assume that every month has the same amount of increment for year 1: $\Delta 1 = (T_1 - T_0)/12$. Since the total number of one year is 12 (an even number), the average of monthly GDP of June and July equals: $T_1/12$. Then,

$T_{1,1} = T_1/12 - 5.5\Delta 1 = T_1/12 - 5.5(T_1 - T_0)/12$, $T_{1,2} = T_{1,1} + \Delta 1$, $T_{1,3} = T_{1,2} + \Delta 1$ …

Then for year 2, by assuming that the GDP increment for every month is the same, i.e., $\delta 2$, we have the following equation:

$T_2 = T_{2,1} + T_{2,2} + ... + T_{2,12} = (T_{1,12} + \delta 2) + (T_{1,12} + 12\delta 2) = 12T_{1,12} + 102\delta 2$,

Then, $\delta 2 = (T_2 - 12T_{1,12})/102$

Therefore,
$T_{2,1} = T_{1,12} + \delta 2 = T_{1,12} + (T_2 - 12T_{1,12})/102\,\mathrm{T2}$,
$T_{2,2} = T_{2,1} + \delta 2$, $T_{2,3} = T_{2,2} + \delta 2$, … $T_{2,12} = T_{2,11} + \delta 2$,
$T_{3,1} = T_{2,12} + \delta 3 = T_{2,12} + (T_3 - 12T_{2,12})/102$,
and $T_{3,2} = T_{3,1} + \delta 3$ …

With this calculation method, we will have the monthly GDP as the following trend:

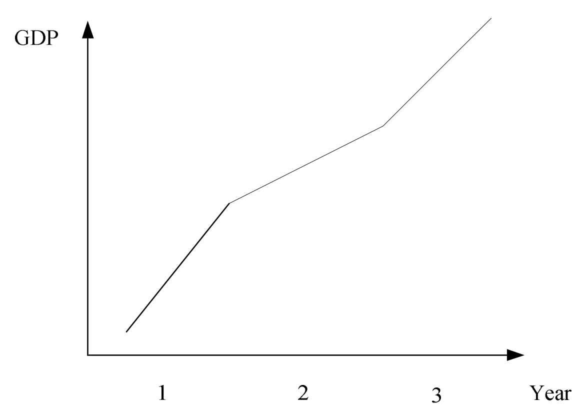

Figure.1 Monthly GDP trend

A3. Other Tables

Table A1. Domestic Demand Elasticity for Corn (OLS)

Importers	δ_0 (intercept)	δ_1 (corn price)	δ_2 (per cap income)	δ_3 (population)	δ_4 (wheat price)	R^2
Algeria	3.272**	-0.731**	0.312	0.919***	0.031	0.906
	(1.378)	(0.318)	(0.280)	(0.144)	(0.917)	
Brazil	9.213***	-0.073*	-0.278	0.478***	0.191*	0.914
	(0.706)	(0.040)	(0.283)	(0.165)	(0.088)	
China	10.075***	0.020	0.336***	-0.027	0.080	0.983
	(0.294)	(0.032)	(0.064)	(0.107)	(0.047)	
Egypt	6.356***	-0.205**	0.302***	0.252***	0.224*	0.927
	(0.594)	(0.096)	(0.069)	(0.044)	(0.120)	
India	7.737***	0.024	0.403***	-0.097*		0.973
	(0.092)	(0.070)	(0.054)	(0.046)		
Japan	9.727***	-0.073	-0.314**	0.385***	0.096	0.922
	(0.447)	(0.058)	(0.116)	(0.063)	(0.103)	
Japan†	9.875***	-0.093	-0.043	0.0143	0.122	0.324
	(0.995)	(0.104)	(0.190)	(0.016)	(0.142)	
Korea	6.298***	-0.527***	0.011	0.621***	0.187	0.974
	(0.610)	(0.164)	(0.097)	(0.089)	(0.146)	
Mexico	6.498***	-0.399***	0.643***	0.033	0.163	0.877
	(0.729)	(0.116)	(0.272)	(0.124)	(0.113)	

Notes: Time series: 1976-2009. Standard error is in parenthesis. †: These prices are collected from Japan Customs, from 1994 to 2007. Dependent variable: Domestic consumption of corn at time *t* of importer *i*'s. Explanatory variable are the per capita income and population of county *i*.
*denotes statistical significance at the 0.10 level.
** denotes statistical significance at the 0.05 level.
*** denotes statistical significance at the 0.01 level.

Table A2. Domestic Demand Elasticity for Corn (REML)

Importers	δ_0 (intercept)	δ_1 (corn price)	δ_2 (Per cap income)	δ_3 (population)
Algeria	5.165***	0.116	-0.192	0.847***
	(1.273)	(0.305)	(0.418)	(0.228)
Brazil	9.499	-0.033	0.199	-0.010
	(897.76)	(0.031)	(0.192)	(0.116)
China	10.474	0.004	0.252**	0.068
	(193.67)	(0.017)	(0.107)	(0.159)
Egypt	8.295	0.029	0.016	0.161
	(393.12)	(0.078)	(0.104)	(0.103)
India	7.744***	-0.003	0.414***	-0.098
	(0.125)	(0.068)	(0.065)	(0.055)
Japan	8.557***	-0.039	0.103	0.180***
	(0.667)	(0.033)	(0.148)	(0.059)
Japan†	11.131	0.019	-0.256	0.005
	(131.28)	(0.032)	(0.241)	(0.028)
Korea	6.957***	-0.371**	0.071	0.587***
	(0.277)	(0.138)	(0.105)	(0.101)
Mexico	8.705	0.415	0.246	0.052
	(481.86)	(0.069)	(0.184)	(0.078)

Notes: Time series: 1976-2009. Standard error is in parenthesis. †: These prices are collected from Japan Customs, from 1994 to 2007. Dependent variable: Domestic consumption of corn at time *t* of importer *i*'s. Explanatory variable are the per capita income and population of county *i*.
*denotes statistical significance at the 0.10 level.
** denotes statistical significance at the 0.05 level.
*** denotes statistical significance at the 0.01 level.

Table A3. Domestic Demand Elasticity for Corn (REML)

Importers	δ_0 (intercept)	δ_1 (corn price)	δ_2 (per cap income)	δ_3 (population)	δ_4 (wheat price)
Algeria	8.634	0.401	-0.527	0.548	-0.302
	(1809.51)	(0.342)	(0.448)	(0.320)	(0.271)
Brazil	9.240	-0.034	0.122	0.050	0.082
	(434.7)	(0.032)	(0.203)	(0.124)	(0.067)
China	10.134***	-0.002	0.235**	0.120	0.052*
	(0.253)	(0.016)	(0.097)	(0.147)	(0.028)
Egypt	8.015	0.008	0.036	0.162	0.047
	(318.24)	(0.093)	(0.115)	(0.133)	(0.109)
Japan	8.456***	-0.061	0.068	0.193***	0.050
	(0.681)	(0.045)	(0.155)	(0.061)	(0.068)
Japan†	11.567	-0.077	-0.346	0.010	0.144
	(114.96)	(0.078)	(0.241)	(0.027)	(0.107)
Korea	6.215***	-0.493***	0.012	0.623***	0.197
	(0.682)	(0.172)	(0.117)	(0.106)	(0.165)
Mexico	8.697	-0.043	0.257	0.049	-0.006
	(437.17)	(0.551)	(0.200)	(0.081)	(0.037)

Notes: Time series: 1976-2007. Standard error is in parenthesis. †: These prices are collected from Japan Customs, from 1994 to 2007. Dependent variable: Domestic consumption of corn at time *t* of importer *i'*s. Explanatory variable are the per capita income, population of county *i* and wheat prices.
*denotes statistical significance at the 0.10 level.
** denotes statistical significance at the 0.05 level.
*** denotes statistical significance at the 0.01 level.

Table A4. Estimation of Domestic Demand Elasticities for Wheat (OLS)

Importers	δ_0 (intercept)	δ_1 (wheat price)	δ_2 (per cap income)	δ_3 (population)	δ_4 (corn price)	R^2
Algeria	6.422***	0.115*	-0.025	0.596***	-0.101	0.965
	(0.336)	(0.063)	(0.044)	(0.031)	(0.071)	
Brazil	8.168***	-0.023	-0.002	0.322***	-0.044	0.858
	(0.507)	(0.091)	(0.121)	(0.106)	(0.052)	
China	10.382***	0.124*	-0.330***	0.847***	-0.021	0.921
	(0.267)	(0.069)	(0.065)	(0.112)	(0.038)	
Egypt	6.214***	0.178***	0.125***	0.450***	-0.042**	0.985
	(0.229)	(0.036)	(0.031)	(0.030)	(0.020)	
Japan	8.187***	-0.027	0.091*	-0.078	0.049	0.262
	(0.237)	(0.061)	(0.053)	(0.051)	(0.053)	
Japan†	8.384***	-0.052	0.037	-0.034**	0.040	0.905
	(0.430)	(0.033)	(0.075)	(0.007)	(0.027)	
Korea	10.483***	-1.336***	0.439	-0.060	1.022	0.712
	(1.088)	(0.369)	(0.283)	(0.464)	(0.387)	
Mexico	7.107***	-0.140**	0.145**	0.027***	0.051	0.938
	(0.325)	(0.055)	(0.067)	(0.054)	(0.068)	

Notes: Time series: 1971-2007. Standard error is in parenthesis. †: These prices are collected from Japan Customs, from 1994 to 2007. Dependent variable: Domestic consumption of wheat at time *t* of importer *i*'s. Explanatory variable are the per capita income, population of county *i*. and corn prices.
*denotes statistical significance at the 0.10 level.
** denotes statistical significance at the 0.05 level.
*** denotes statistical significance at the 0.01 level.

Table A5. Domestic Demand Elasticity for Wheat (REML)

Importers	δ_0 (intercept)	δ_1 (wheat price)	δ_2 (per cap income)	δ_3 (population)
Algeria	6.851	0.010	0.170*	0.114
	(485.71)	(0.042)	(0.084)	(0.071)
Brazil	7.714***	-0.017	0.092	0.202***
	(0.411)	(0.055)	(0.073)	(0.056)
China	9.793***	-0.011	0.072	0.367***
	(0.535)	(0.039)	(0.083)	(0.079)
Egypt	6.699	0.136***	(0.041)	0.488***
	(0.240)	(0.031)	0.157	(0.041)
Japan	8.519***	-0.010	0.010	0.046**
	(0.209)	(0.017)	(0.024)	(0.022)
Japan†	8.807***	-0.011	-0.008	-0.019
	(0.585)	(0.022)	(0.109)	(0.012)
Korea	9.531***	-0.594***	0.037	0.384**
	(1.026)	(0.180)	(0.120)	(0.180)
Mexico	6.930***	-0.094***	0.163***	0.219***
	(0.304)	(0.034)	(0.050)	(0.035)

Notes: Time series: 1971-2007. Standard error is in parenthesis. †: These prices are collected from Japan Customs, from 1994 to 2007. Dependent variable: Domestic consumption of wheat at time *t* of importer *i*'s. Explanatory variable are the per capita income, population of county *i*.
*denotes statistical significance at the 0.10 level.
** denotes statistical significance at the 0.05 level.
*** denotes statistical significance at the 0.01 level.

Table A6. Estimation of Domestic Demand Elasticities for Wheat (REML)

Importers	δ_0 (intercept)	δ_1 (wheat price)	δ_2 (per cap income)	δ_3 (population)	δ_4 (corn price)
Algeria	6.385***	0.043	0.036	0.573***	-0.076
	(0.505)	(0.051)	(0.081)	(0.074)	(0.057)
Brazil	8.015***	0.009	0.000	0.309***	-0.017
	(0.437	(0.068)	(0.088)	(0.098)	(0.035)
China	9.511	0.022	-0.072	0.714***	-0.007
	(376.69)	(0.057)	(0.121)	(0.203)	(0.023)
Egypt	6.904***	0.128***	0.036	0.502***	-0.036
	(0.274)	(0.036)	(0.043)	(0.059)	(0.027)
Japan	8.502**	0.020	0.002	0.026	-0.014
	(0.259)	(0.030)	(0.041)	(0.055)	(0.030)
Japan†	8.586***	-0.045	0.000	-0.018	0.039
	(0.521)	(0.030)	(0.094)	(0.010)	(0.024)
Korea	10.914***	-1.236**	0.219	0.283	0.902**
	(1.231)	(0.347)	(0.326)	(0.568)	(0.341)
Mexico	7.256***	-0.089**	0.098	0.293***	-0.052
	(0.406)	(0.040)	(0.073)	(0.070)	(0.073)

Notes: Time series: 1971-2007. Standard error is in parenthesis. †: These prices are collected from Japan Customs, from 1994 to 2007. All prices are divided by GDP deflator. Dependent variable: Domestic consumption of wheat at time *t* of importer *i'*s.

Explanatory variable are the per capita income, population of county *i* and corn prices.

*denotes statistical significance at the 0.10 level.

** denotes statistical significance at the 0.05 level.

*** denotes statistical significance at the 0.01 level.

Table A7. Domestic demand elasticity for soybeans (OLS)

Importers	δ_0 (intercept)	δ_1 (soybeans price)	δ_2 (per cap income)	δ_3 (population)	δ_4 (wheat price)	R^2
Brazil	4.719***	-0.040	0.119**	0.804***	-0.069	0.991
	(0.335)	(0.057)	(0.042)	(0.052)	(0.054)	
China	0.389	0.094	1.670***	0.396	-1.111	0.962
	(2.429)	(0.474)	(0.286)	(0.389)	(0.478)	
Egypt	-5.459	-0.243	1.209**	0.509	0.339	0.756
	(4.716)	(0.789)	(0.566)	(0.674)	(0.638)	
Indonesia	-1.370	-0.421	-0.033	1.899*		0.321
	(6.184)	(1.373)	(0.829)	(1.001)		
Japan	5.598***	0.103	0.024	0.131	-0.068	0.562
	(0.655)	(0.137)	(0.084)	(0.131)	(0.122)	
Japan†	13.022***	-0.115	-1.201**	0.102**	0.135	0.762
	(2.266)	(0.424)	(0.424)	(0.038)	(0.177)	
Mexico	0.806	0.011	0.333**	0.912***	-0.070	0.943
	(0.865)	(0.051)	(0.153)	(0.152)	(0.122)	

Notes: Time series: 1968-2007. Standard error is in parenthesis. †: These prices are collected from Japan Customs, from 1994 to 2007. All prices are divided by GDP deflator. Dependent variable: Domestic consumption of wheat at time *t* of importer *i*'s. Explanatory variable are the per capita income, population of county *i* and wheat prices.
*denotes statistical significance at the 0.10 level.
** denotes statistical significance at the 0.05 level.
*** denotes statistical significance at the 0.01 level.

Table A8. Domestic Demand Elasticity for Soybeans (REML)

Importers	δ_0 (intercept)	δ_1 (soybeans price)	δ_2 (per cap income)	δ_3 (population)	δ_4 (wheat price)
Brazil	4.759***	-0.041	0.119**	0.801***	-0.073
	(0.353)	(0.059)	(0.042)	(0.057)	(0.054)
China	2.414	-0.025	0.60	0.947	-0.710**
	(1221.34)	(0.491)	(0.639)	(0.772)	(0.320)
Egypt	-3.063	0.168	0.859	0.956	-0.369
	(4.540)	(0.456)	(0.672)	(0.982)	(0.443)
Indonesia	-0.355	-0.616	0.043	1.764	
	(6.564)	(1.410)	(0.868)	(1.107)	
Japan	5.992	0.043	-0.037	0.339**	-0.114*
	(334.37)	(0.063)	(0.083)	(0.153)	(0.058)
Japan†	12.170**	-0.026	-1.041*	0.054	0.072
	(2.735)	(0.107)	(0.506)	(0.056)	(0.133)
Mexico	1.241	-0.007	0.312*	0.953***	-0.130*
	(1.013)	(0.040)	(0.196)	(0.198)	(0.127)
EU-27	13.313	-0.592*	-0.644	0.297	1.944*
(Rotterdam)	(0.463)	(0.074)	(0.715)	(0.138)	(0.062)

Notes: Time series: 1975-2007. Standard error is in parenthesis. †: data are collected from Japan Customs, annual, started from 1994 to 2007. EU-27 is using Rotterdam prices, time starts from 1999 to 2007. All prices are divided by GDP deflator. Dependent variable: Domestic consumption of wheat at time *t* of importer *i*'s. Explanatory variable are the per capita income, population of county *i* and wheat prices.
*denotes statistical significance at the 0.10 level.
** denotes statistical significance at the 0.05 level.
*** denotes statistical significance at the 0.01 level.

Table A9 Short-run Domestic Supply Elasticity for Corn (OLS) (Unit Value-Free alongside ship)

Importers	α_0 (intercept)	α_1 (lagged domestic corn production)	α_2 (lagged corn price)	R^2
Brazil	2.373***	0.776***	-0.058	0.841
	(0.715)	(0.071)	(0.048)	
China	0.927	0.922***	0.005	0.910
	(0.962)	(0.087)	(0.028)	
Egypt	0.381	0.957***	0.000	0.968
	(0.286)	(0.035)	(0.011)	
India	1.941*	0.742***	0.283*	0.931
	(0.100)	(0.123)	(0.103)	
Japan	0.066	0.871***	-0.078	0.938
	(0.075)	(0.063)	(0.113)	
Japan†	-0.003*	0.509**	0.019	0.462
	(0.048)	(0.181)	(0.163)	
Korea	1.208*	0.736***	-0.006	0.611
	(0.486)	(0.108)	(0.035)	
Mexico	0.875	0.913***	-0.019	0.828
	(0.714)	(0.075)	(0.032)	

Notes: Standard error is in parenthesis. Time series is 1976-2007. †: data are collected from Japan Customs, annual, started from 1995to 2008.Dependent variable: Domestic output of corn at time *t* of importer *i*'s. Explanatory variables are the output of corn in country *i* at time *t-1*, annual US producer price at time *t-1* and additional potential variable technology trend.

*denotes statistical significance at the 0.10 level.

** denotes statistical significance at the 0.05 level.

*** denotes statistical significance at the 0.01 level.

Table A10 Short-run Domestic Supply Elasticity for Corn (OLS, with FAO producer price)

Importers	α_0 (intercept)	α_1 (lagged domestic corn production)	α_2 (lagged corn price)	α_3 (lagged wheat price)	α_4 (trend)	R^2
Brazil	3.835 (3.678)	0.643 (0.367)	-0.510 (0.509)	0.058 (0.389)	0.191 (0.089)	0.659
China	12.738*** (3.661)	-0.161 (0.332)	-0.077 (0.088)	0.347 (0.179)	0.184 (0.077)	0.662
Egypt	6.745*** (2.040)	0.202 (0.235)	0.068* (0.035)	0.005** (0.090)	0.016 (0.039)	0.733
France	20.632*** (5.371)	-0.256 (0.318)	0.195 (0.365)	-0.311* (0.148)	0.051 (0.094)	0.329
India	0.737 (3.301)	0.619* (0.312)	1.528* (0.809)		0.112 (0.077)	0.767
Italy	13.168** (5.244)	0.165 (0.329)	0.551** (0.240)	-0.393** (0.124)	0.184*** (0.050)	0.791
Korea	8.832 (4.944)	-0.222 (0.438)	-0.514 (0.652)	-1.206 (1.238)	-0.006 (0.126)	0.218
Mexico	8.442** (2.897)	0.117 (0.305)	0.331 (0.322)	-0.316* (0.193)	0.118 (0.085)	0.614

Notes: P-value is in parenthesis. Time series is 1992-2007. Dependent variable: Domestic output of corn at time *t* of importer *i*'s. Explanatory variable are the output of corn in country *i* at time *t-1*, annual US producer price in time *t-1* and additional potential variables: lagged wheat price and technology trend.
*denotes statistical significance at the 0.10 level.
** denotes statistical significance at the 0.05 level.
*** denotes statistical significance at the 0.01 level.

Table A11 Short-run Domestic Supply Elasticity for Corn (REML) (Unit Value-Free alongside ship)

Importers	α_0 (intercept)	α_1 (lagged domestic corn production)	α_2 (lagged corn price)	α_3 (tech)	α_4 (lagged wheat price)
Brazil	4.028***	0.595***	-0.023	0.112*	-0.125
	(1.093)	(0.116)	(0.062)	(0.050)	(0.103)
China	6.039***	0.402*	0.001	0.301**	0.014
	(1.989)	(0.197)	(0.027)	(0.122)	(0.126)
Egypt	1.790***	0.768***	-0.002	0.066**	0.010
	(0.620)	(0.086)	(0.012)	(0.026)	(0.025)
India	9.200	0.306	0.393**	0.070	-0.725
	(2.549)	(0.247)	(0.100)	(0.047)	(0.203)
Japan	2.258***	0.117	0.015	-0.646***	-0.120
	(0.444)	(0.158)	(0.031)	(0.129)	(0.154)
Japan†	1.230	-0.359	-0.115	-0.647	0.201
	(1841.81)	(0.260)	(0.510)	(0.159)	(0.672)
Korea	2.287***	0.667***	0.038	-0.147***	-0.456*
	(0.518)	(0.095)	(0.034)	(0.040)	(0.198)
Mexico	1.513	0.827***	-0.024	0.067	0.008
	(0.961)	(0.105)	(0.033)	(0.041)	(0.110)

Notes: Standard error is in parenthesis. Time series is 1976-2009. Dependent variable: Domestic output of corn at time *t* of importer *i*'s. Explanatory variable are the output of corn in country *i* at time *t-1*, corn price in time *t-1* and additional potential variables: technology trend and lagged wheat price.
*denotes statistical significance at the 0.10 level.
** denotes statistical significance at the 0.05 level.
*** denotes statistical significance at the 0.01 level.

Table A12 Short-run Domestic Supply Elasticity for Wheat (OLS, with FAO producer price)

Importers	α_0 (intercept)	α_1 (lagged domestic wheat production)	α_2 (lagged wheat price)	R^2
Brazil	8.125***	-0.254*	1.933*	0.621
	(1.773)	(0.265)	(0.540)	
China	4.247*	0.598***	0.222**	0.621
	(1.990)	(0.175)	(0.093)	
Egypt	1.067	0.874***	0.034	0.774
	(1.205)	(0.163)	(0.261)	
France	18.685***	-0.073	-0.228*	0.245
	(0.001)	(0.779)	(0.063)	
Italy	13.736***	0.131	0.056	0.033
	(0.003)	(0.604)	(0.721)	
Japan	-0.556	0.740***	0.964*	0.843
	(0.856)	(0.129)	(0.335)	
Korea	-10.083	0.317	5.382	0.253
	(7.535)	(0.241)	(3.517)	
Mexico	5.445***	0.300	0.225*	0.450
	(1.707)	(0.217)	(0.115)	

Notes: Standard error is in parenthesis. Time series is 1992-2007. Dependent variable: Domestic output of wheat at time *t* of importer *i*'s. Explanatory variable are the output of wheat in country *i* at time *t-1*, unit value in time *t-1*.
*denotes statistical significance at the 0.10 level.
** denotes statistical significance at the 0.05 level.
*** denotes statistical significance at the 0.01 level.

Table A13 Short-run Domestic Supply Elasticity for Wheat (OLS with FAO producer price)

Importers	α_0 (intercept)	α_1 (lagged domestic wheat production)	α_2 (lagged wheat price)	α_3 (lagged corn price)	α_4 (trend)	R^2
Brazil	9.579***	-0.439	2.407**	-0.876	0.030	0.744
	(1.763)	(0.259)	(0.759)	(0.739)	(0.023)	
China	5.839**	0.451**	0.340***	0.008	-0.008	0.718
	(2.109)	(0.186)	(0.099)	(0.050)	(0.005)	
Egypt	7.529**	0.091	0.049	0.013	0.034**	0.867
	(2.596)	(0.329)	(0.220)	(0.085)	(0.013)	
France	22.507***	-0.304	-0.255**	0.130	0.015	0.444
	(4.596)	(0.265)	(0.265)	(0.297)	(0.011)	
Italy	19.766***	-0.258	-0.000	0.311	-0.003	0.300
	(4.670)	(0.299)	(0.148)	(0.349)	(0.012)	
Japan	-2.910	0.792***	2.493	-0.679	-0.0166	0.847
	(4.912)	(0.178)	(2.891)	(1.666)	(0.035)	
Korea	-4.991	0.695*	2.879	-0.445	0.034	0.578
	(14.213)	(0.334)	(5.319)	(2.591)	(0.070)	
Mexico	2.793**	0.635***	0.167*	0.167*	0.167*	0.486
	(0.946)	(0.124)	(0.095)	(0.095)	(0.095)	

Notes: Standard error is in parenthesis. Time series is 1992-2007. Dependent variable: Domestic output of wheat at time *t* of importer *i*'s. Explanatory variable are the output of wheat in country *i* at time *t-1*, unit value in time *t-1,* lagged corn price and trend.
*denotes statistical significance at the 0.10 level.
** denotes statistical significance at the 0.05 level.
*** denotes statistical significance at the 0.01 level.

Table A14 Short-run Domestic Supply Elasticity for Wheat (REML, with Unit Value)

Importers	α_0 (intercept)	α_1 (lagged domestic wheat production)	α_2 (lagged wheat price)	α_3 (trend)	α_4 (lagged corn price)
Brazil	7.191***	0.075	0.090	0.098	-0.022
	(1.947)	(0.213)	(0.362)	(0.418)	(0.164)
China	8.764***	0.177	0.196**	0.122	-0.022
	(2.023)	(0.201)	(0.085)	(0.168)	(0.038)
Egypt	0.570	0.879***	-0.020	0.189**	-0.070
	(0.418)	(0.078)	(0.146)	(0.075)	(0.142)
Japan	3.241***	0.448**	-0.566**	0.211**	0.432*
	(0.907)	(0.164)	(0.252)	(0.099)	(0.227)
Japan†	5.475***	0.067	0.607	0.206**	-0.386
	(1.235)	(0.185)	(0.362)	(0.069)	(0.277)
Korea	2.502	0.164	0.402	-0.321	-0.256
	(1.820)	(0.196)	(1.180)	(0.504)	(1.073)
Mexico	2.793**	0.635***	0.167*	0.167*	0.167*
	(0.946)	(0.124)	(0.095)	(0.095)	(0.095)

Notes: Standard error is in parenthesis. Time series is 1971-2008. †: data are collected from Japan Customs, annual, started from 1995to 2008. Dependent variable: Domestic output of wheat at time *t* of importer *i*'s. Explanatory variable are the output of wheat in country *i* at time *t-1*, its unit value in time *t-1*, technology trend and lagged wheat price.

*denotes statistical significance at the 0.10 level.

** denotes statistical significance at the 0.05 level.

*** denotes statistical significance at the 0.01 level.

Table A15 Short-run Domestic Supply Elasticity for Soybeans (OLS, with unit value)

Importers	α_0 (intercept)	α_1 (lagged domestic soybeans production)	α_2 (lagged soybeans price)	R^2
Brazil	6.770***	0.223*	-0.234	
	(0.001)	(0.024)	(0.345)	0.524
China	-0.100	0.991***	0.137	
	(0.540)	(0.001)	(0.242)	0.988
Egypt	-0.430	0.920***	0.430**	
	(0.219)	(0.001)	(0.006)	0.874
Italy	1.737*	0.675**	0.063	
	(0.071)	(0.003)	(0.769)	0.643
Japan	1.219***	0.812***	-0.008	
	(0.001)	(0.001)	(0.830)	0.878
Japan†	3.643*	0.468*	-0.227*	
	(0.043)	(0.072)	(0.092)	
Mexico	0.537*	0.887***	0.128*	
	(0.027)	(0.001)	(0.016)	0.937
Turkey	2.030*	0.723***	-0.692	
	(0.055)	(0.001)	(0.210)	0.650

Notes: Standard error is in parenthesis. Time series is 1968-2007. †: data are collected from Japan Customs, annual, started from 1995to 2008. Dependent variable: Domestic output of soybeans at time *t* of importer *i*'s. Explanatory variables are the output of soybeans in country *i* at time *t-1*, unit value in time *t-1* .
*denotes statistical significance at the 0.10 level.
** denotes statistical significance at the 0.05 level.
*** denotes statistical significance at the 0.01 level.

Table A16 Short-run Domestic Supply Elasticity for Soybeans (OLS, with FAO producer price)

Importers	α_0 (intercept)	α_1 (lagged domestic soybeans production)	α_2 (lagged soybeans price)	α_3 (trend)	R^2
Brazil	1.758	0.779***	0.003	0.077	0.918
	(1.541)	(0.197)	(0.103)	(0.056)	
China	0.931	0.866***	0.058	0.061	0.953
	(1.454)	(0.209)	(0.244)	(0.262)	
Egypt	-2.211*	0.368*	1.592*	0.515*	0.897
	(0.952)	(0.248)	(0.546)	(0.213)	
France	3.102	0.804***	0.335	-0.461*	0.815
	(0.108)	(0.001)	(0.573)	(0.014)	
Italy	2.294	0.507	0.217	0.151	0.594
	(2.313)	(0.387)	(0.878)	(0.224)	
Japan	4.105***	0.515***	-0.340***	-0.020	0.837
	(0.179)	(0.163)	(0.085)	(0.022)	
Mexico	1.302	0.708***	0.191	0.170**	0.861
	(1.189)	(0.178)	(0.164)	(0.075)	
Turkey	1.187	0.556*	-0.083	0.264	0.536
	(0.497)	(0.261)	(0.601)	(0.308)	

Notes: Standard error is in parenthesis. Time series is 1992-2007. Dependent variable: Domestic output of soybeans at time *t* of importer *i*'s. Explanatory variable are the output of soybeans in country *i* at time *t-1*, annual US producer price in time *t-1* and additional potential variable technology trend.
*denotes statistical significance at the 0.10 level.
** denotes statistical significance at the 0.05 level.
*** denotes statistical significance at the 0.01 level.